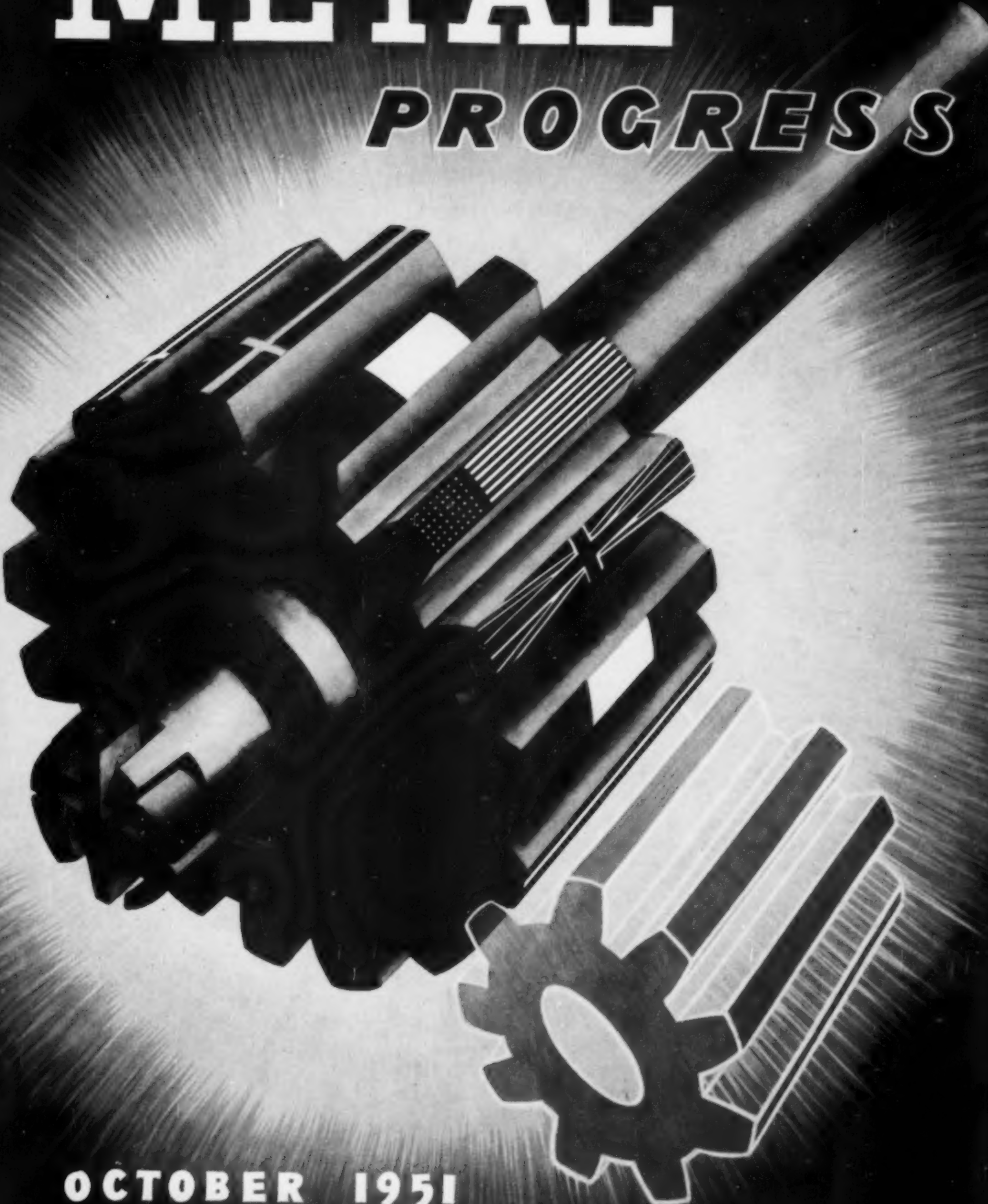
METAL
PROGRESS



OCTOBER 1951

Here's what metal working management will want to know about Microcarb Control

NOTHING else can do what Microcarb does in controlling the carburization of steel parts. Gears, shafts, cams, bearings and all the other items which owe some of their high quality and low cost to the carburizing process can now be made even better—and possibly at even lower cost.

The cause of such improvement is simply that Microcarb measures directly the carburizing "strength" of the furnace gases which supply carbon to the work being processed.

Heretofore many carburizing equipments have measured the amount of carbonaceous material fed into the furnace, but none has **directly** measured the active carbon in the hot furnace gas. For a comparison, think of heating your home by putting fuel in the furnace, without a thermometer to tell the temperature. Keeping your home at the same temperature day in and day out would then be an art rather than a science; some one person's judgment would have to be accepted, but there'd be no check. The comparable condition has heretofore been quite common in carburizing operations, everywhere.

Microcarb ends that uncertainty; it measures and controls carbon directly. Heat-treaters simply set the Microcarb Controller at 90 if they wish to carburize to ninety carbon. "The carbon you set is the carbon you get".

The "reason why" for Microcarb is its carbon detecting element. This invention, called a Carbohm, is an engineering rarity—a truly new device for sensing a change in its surroundings.

Basically, a Carbohm is a wire, made of an alloy which will either absorb carbon from the furnace atmosphere, or lose it to the atmosphere, until it and the atmosphere are in equilibrium, carbon-wise.

With every change in the wire's carbon content, there's a corresponding change in its electrical resistance. The two Microcarb instruments—Controller and Carbon Recorder—translate this resistance directly into terms of percent carbon, control on that basis and record the result.

Only Homocarb carburizing equipment of our new Series H can be used with Microcarb, because the furnace and its temperature control must be designed to meet the needs of atmosphere regulation. Specific features are a soundly designed electric furnace with solid-bottom retort, improved fan housing and work support, and aerodynamically designed discharge jets. Micromax temperature control of the Duration-Adjusting Type is included.

Microcarb is many things to many men, especially in defense work.

To top management, Microcarb means better competitive position (for the individual company) quality-wise and possibly cost-wise. Also, it meets the usual desire for process control which is fully automatic.

To production executives, Microcarb means closer following of production schedules, because carburizing speeds and results are definitely more predictable than ever before.

To personnel executives, Microcarb means cleaner, more attractive working conditions. And, if the heat-treat uses incentive pay, Microcarb helps heat-treaters increase their earnings, because it makes it easier for them to apply their skill and therefore increase their productivity.

To metallurgists, Microcarb means some or all of the above advantages, plus a tightening of technique such as every technician likes. "New" or hard-to-handle steels hold fewer puzzles. Standard steels emerge with closer specifications. The heat-treat takes another long step toward becoming a manufacturing laboratory.

Let us send you further facts about this new Microcarb Control. Ask our nearest office, or 4927 Stenton Ave., Phila. 44, Pa.

LEEDS & NORTHRUP

Jrl. Ad. TD4-623(4)

Metal Progress is published and copyrighted, 1951, by American Society for Metals, 7301 Euclid Avenue, Cleveland, Ohio. Issued monthly; subscriptions $7.50 a year. Entered as second-class matter Feb. 7, 1921, at the post office at Cleveland, Ohio, under the act of March 3, 1879.

AIRCO ACCURACY... PRECISION... OPERATING ECONOMY

designed into the all new

AIRCO NO.50 TRAVOGRAPH

GAS CUTTING MACHINE

Airco's NEW No. 50 Travograph is a rugged, all-welded gas cutting machine. Its massive, long-lived design is engineered to give fingertip sensitivity to all production operations. Used as a basic tool for multi-torch shape cutting, squaring or beveling, its outstanding accuracy slashes reject loss and working costs to a minimum.

Today's most modern production tool, the rugged new Airco No. 50 Travograph precision-cuts steel—light plates, heavy slabs, billets, forgings—to close tolerances. Here are the reasons for its remarkable exactness . . . the "why" it guarantees faithful reproduction.

1. All-welded construction provides a combination of ruggedness, resistance to vibration, and precision operation.
2. Rigidity built into the torch-bearing pantograph arms enables the torch bar to support a uniform load of *500 lbs!*
3. Perfectly-balanced when properly set on 16′ rails.
4. Ball bearings in the hinge joints make it extremely smooth operating.

For greatest operating flexibility, the new No. 50 Travograph can be equipped with three distinctly different tracing devices—manual, magnetic, or the full-automatic "Electronic Bloodhound". The "Electronic Bloodhound" needs only an outline drawing or silhouette to cut the most intricate shapes smoothly, sharply, quickly . . . and with extreme accuracy.

If your production line requires quantity flame shaping operations . . . and if close precision cutting would lower your finish-machining costs . . . it will pay you to investigate Airco's new No. 50 Travograph. For complete information write your nearest Airco office for the new catalog just coming off the press.

AIRCO

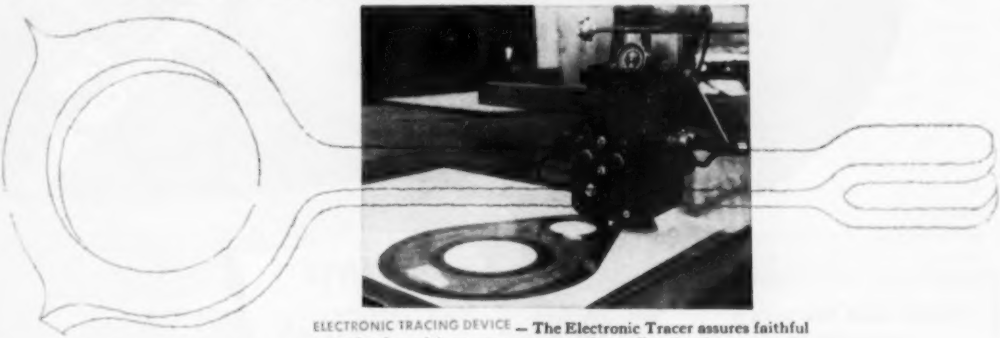
AIR REDUCTION

Divisions of Air Reduction Company, Incorporated

Dealers and Offices in Principal Cities

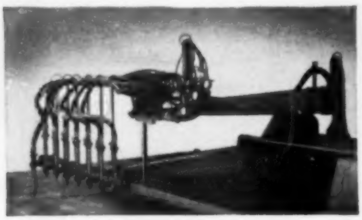
AIR REDUCTION . . . PIONEER

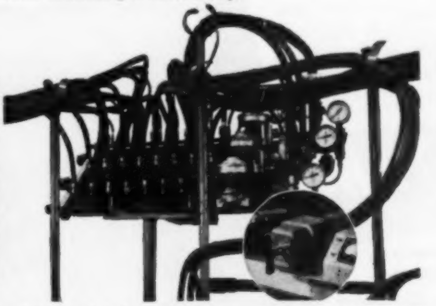
WIDE CUTTING RANGE — **The No. 50 Travograph cuts circles up to 144" and any shape that does not exceed 92" x 144" on one side. Carriage speeds range from 2" to 35" per minute on the low side; 10" to 168" on the high side, permitting a wide cutting range and allowing high speed positioning over the work.**



ELECTRONIC TRACING DEVICE — **The Electronic Tracer assures faithful reproduction with extreme accuracy. An outline drawing or a paper cut-out, is easily prepared. Inside and outside square corners, obtuse and acute angles, long slim projections, narrow slots and intricate contours — in any quantity — are all possible with this tracer. It follows the outline automatically, and so accurately that in most cases further machining is unnecessary.**

SELF-SUPPORTED MANIFOLD — **This individual pantograph arm supports the entire weight of the gas distribution equipment, and is guided by the tracer bar, so that the manifold-torch relationship remains constant. The useful load capacity of the tracer bar is greatly increased because it carries no gas equipment except torches.**

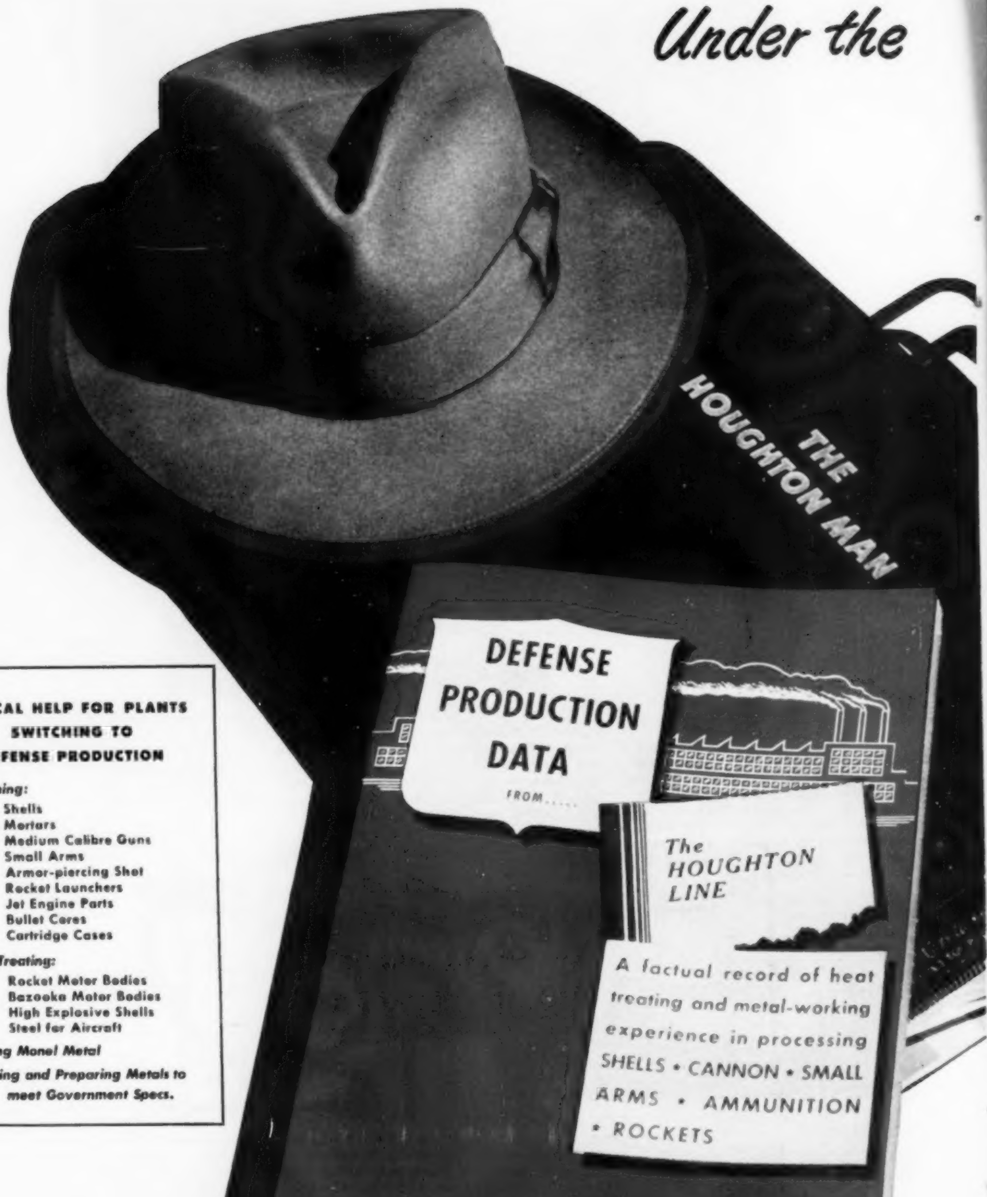




GAS DISTRIBUTION SYSTEM — **A twist of the selector switch located on the remote control box at the "operator's station" gives complete control of preheating gases and cutting oxygen. This operates one to eight torches, and assures a properly adjusted flame for repetitive cutting operations. This remote control is made possible by solenoid operated valves located on the manifold.**

DESIGNERS OF FLAME CUTTING MACHINES FOR EVERY PURPOSE

Under the



TYPICAL HELP FOR PLANTS SWITCHING TO DEFENSE PRODUCTION

Machining:
- Shells
- Mortars
- Medium Calibre Guns
- Small Arms
- Armor-piercing Shot
- Rocket Launchers
- Jet Engine Parts
- Bullet Cores
- Cartridge Cases

Heat Treating:
- Rocket Motor Bodies
- Bazooka Motor Bodies
- High Explosive Shells
- Steel for Aircraft

Forging Monel Metal

Cleaning and Preparing Metals to meet Government Specs.

HOUGHTON PRODUCTS FOR THE METALWORKING INDUSTRY: Cutting Oils and Bases, Drawing Compounds,

Houghton man's hat there's help for you...

• Getting out into the shop as Houghton men are invited to do, they meet up with a whale of a lot of metalworking problems.

They're continually called on for help in solving problems like these: meeting high physicals in the heat treatment of "lean alloy" steels . . . boosting machine output and reducing rejects . . . developing lubrication that stands up under all operating temperatures . . . cleaning metals faster at lower cost . . . preventing idle equipment from rusting . . . deep drawing safely at extreme pressures . . . and so on.

By working on such a wide variety of problems Houghton has accumulated a lot of metalworking "know-how". We keep careful tabs on success stories through research data and field reports. And all of this information is constantly studied to find out how it can be more widely applied to help the whole metalworking industry.

Because of this vast metalworking experience Houghton men are called on repeatedly for aid—particularly by plants faced with unfamiliar conversion problems. Two-thirds of our sales and research organization today, are veterans of World War II production experience.

Now another rearmament program is getting into full swing. Changes on the production line are popping up again. And Houghton men are busy helping customers lick *today's* problems.

Your Houghton man can help you with many of your problems right on the spot. He can also draw on the wealth of production data our research staff has at its fingertips. For example, the list at the left shows some typical help we can offer on defense production today.

Meantime, to make some of our extensive experience immediately available to you, we have put it into quick reference form. Called "Houghton Defense Production Data", this 60-page illustrated book provides you with information that may save endless hours of searching—and costly trial-and-error experimenting.

Get timely help with your conversion problems by sending today for your copy of this valuable book. Fill out and mail the coupon to E. F. Houghton & Co., 303 West Lehigh Avenue, Philadelphia 33, Pa.

E.F. HOUGHTON & CO.
PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

E. F. Houghton & Co.
303 West Lehigh Avenue, Philadelphia 33, Pa.

Please send us a free copy of the new 60-page book, "Houghton Defense Production Data"

Name________________________ Title__________

Company________________________

Address________________________

City______________ Zone______ State__________

Metal Cleaners, Rust Preventives, Foundry Core Binders, Quenching Oils, Salt Bath Materials, Lubricants and Greases

SHORTEST ROUTES to new

Outstanding DYNALOG* Electronic Recorders and Controllers

Dynalog Controller

The extreme simplicity of Dynalog Electronic Instruments results in unmatched accuracy, sensitivity, and speed — plus unequalled freedom from maintenance. Designed to take full advantage of electronic circuits, these instruments provide completely stepless, continuous balancing. Full-scale to complete balance in as little as one second (3 seconds, standard). Dynalog is the only potentiometer that has:

NO SLIDEWIRE **NO GALVANOMETER** **NO HIGH-SPEED BALANCING MOTOR** **NO STANDARDIZING** **NO BATTERY**

INDICATORS, RECORDERS AND CONTROLLERS Available for temperatures up to 2800°F. with thermocouples, and up to 600°F. with resistance bulbs; for pH with Beckman electrodes; for blast air moisture with the Foxboro Dewcel; for force cells and weight cells. Controllers supplied with either pneumatic or electric control systems. For on-off, proportioning, or automatic reset control.

The Multi-Record DYNALOG

Measures and records a point every 6 seconds — up to 6 different points — in 6 distinctive non-blurring colors. The single pen arm positively synchronizes all records in respect to the time arcs on the chart. Records are easy to read; the circular charts are economical and convenient to file.

Multi-Record Dynalog

The Segmental Chart DYNALOG

Records 24 points on one chart at one minute interval per point. 24 points in 25 minutes. Economical for supervisory records on a large number of slowly changing temperature points such as furnace walls and roofs, bearings, etc.

*Reg. U. S. Pat. Off.

RECORDING • CONTROLLING

efficiencies in metal working

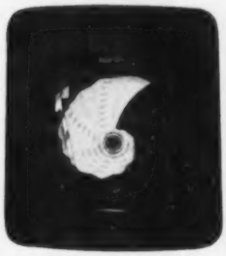
ECONOMICAL TEMPERATURE CONTROL for furnaces and ovens

Top performance of the Type 4000 non-recording controllers has been proven over many years of service. A single motor can operate up to 5 instruments . . . affords large savings in both initial and operating costs. Control is electric . . . action, on-off or proportioning.

Type 4000
Non-Recording Controller

SCHEDULE CONTROL for repetitive time-temperature cycles

When used with Type 4000 controller, this time-temperature cam-setting unit varies control point to carry out any program. Different rates of rise, holding periods and other variations can be combined on the same cam. Mechanism is extremely simple and trouble-free. Aluminum cam blanks, printed with time and temperature scales, are easy to lay out and cut.



Program Controller

STRONG ACID PICKLING with the Type 4000 non-recording temperature controller

Simpler, fewer, larger, and more rugged parts make the Type 4000 particularly free from maintenance problems and expense. The electrical measuring system permits controller to be located any distance from bath, away from corrosive atmosphere.

Foxboro strong-acid thermocouples stand up in severe pickling solutions. Reduce maintenance costs and interruptions in service.

FUEL, AIR, AND WATER PRESSURES

With Foxboro pressure indicators, recorders, or automatic controllers; gas or oil pressures for furnace burners can be maintained efficiently . . . compressors and hydraulic systems controlled accurately . . . steam pressures properly indicated or recorded . . . and many similar functions performed to streamline costs. All standard ranges between 1" of water and 80,000 lb.

Pressure Recorder

FLOW OF FUEL, AIR, WATER, STEAM

Foxboro Flow Meters accurately record flow to show plant, department, or operation consumption of gas, oil, steam, water, or air. For operating pressures up to 5,000 lb. Can be equipped with integrators to totalize flow. On many processes, pressure or temperature records can be combined on the same chart with the record of flow. Also available: automatic flow controllers.

Flow Meter for Fuel, Air and Water

ELECTROPLATING TEMPERATURE CONTROLS

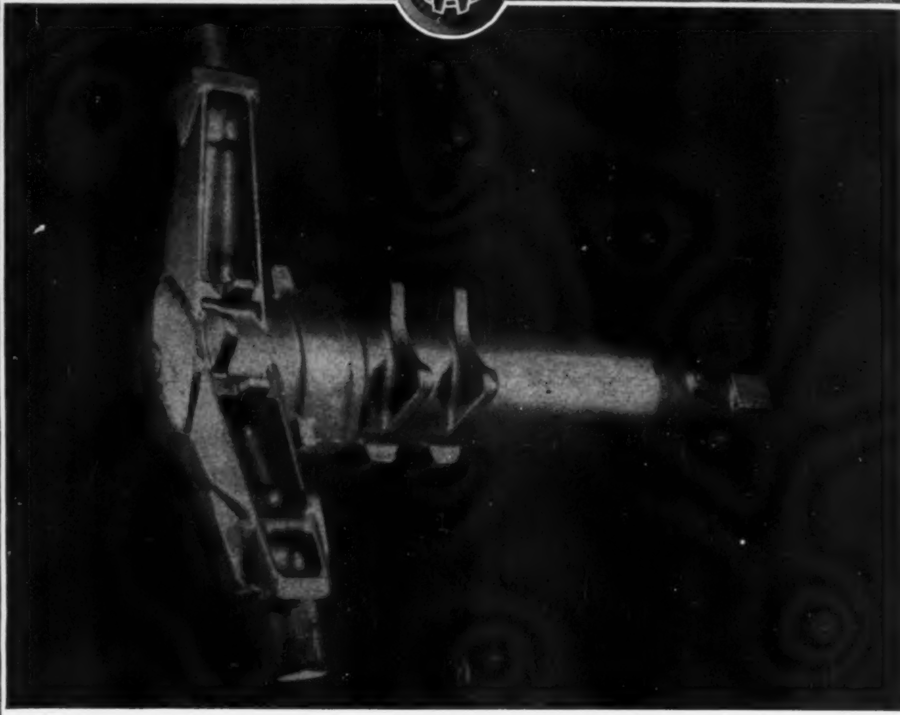
Accurate, automatic control of heating or heating and cooling in plating tanks, cleaning baths, degreasers, and wash tanks by this compact instrument assures top quality at low cost. The Foxboro Model 41 meets the demand for an inexpensive indicating controller that gives unexcelled performance. Bulbs of Type 316 Stainless Steel, to resist corrosion and eliminate maintenance, are standard.

Model 41 Temperature Controller

✓ **Check all the features of these instruments for help in bringing maximum economies to your plant. Write for complete data. The Foxboro Company, 5210 Neponset Ave., Foxboro, Mass., U. S. A.**

INDICATING INSTRUMENTS BY

FOXBORO
REG. U. S. PAT. OFF.

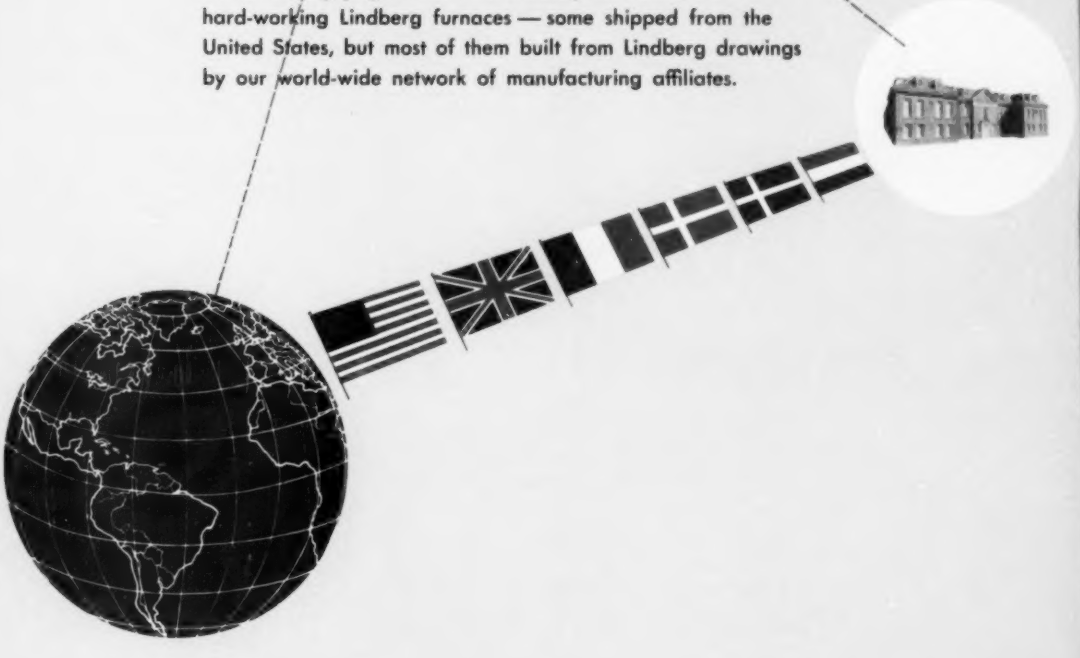


Lindberg paroli universala lingvajo kie ajn metalo estas fabrikid

Yes — "Lindberg speaks the universal language wherever metal is fabricated" — that's the translation of the headline in Esperanto — the universal language!

And in the many parts of the world where Lindberg Furnaces are manufactured and used, you'll find these furnaces speaking another universal language — the one that needs no translation — the language of production men.

The following pages show some foreign installations of hard-working Lindberg furnaces — some shipped from the United States, but most of them built from Lindberg drawings by our world-wide network of manufacturing affiliates.



Lindberg . . . . in any language means finer furnaces

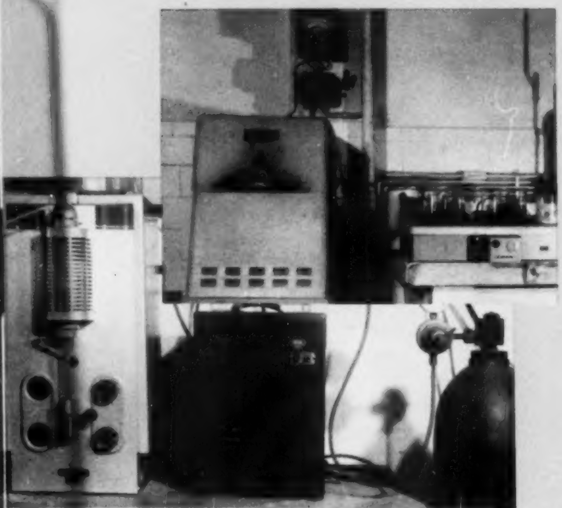
J. Zimmer & Zonen, Amsterdam

Wij stellen het zeer op prijs U hiermede te berichten, dat de Lindberg oven, welke reeds enige jaren met veel succes dag en nacht in ons bedrijf in gebruik is, thans met evenveel succes werkt in onze nieuwe afdeling: Staalharderij.

In onze zeer modern ingerichte loonstaalharderij, waarin voor een paar duizend binnenlandse bedrijven de onderdelen worden gehard, heeft de Lindberg oven veel bijgedragen om onze productie te verhogen.

We beg to inform you herewith that the Lindberg furnace, which has already been successfully day and night in use in our plant, is working at the moment with as much success in our new department: Steelhardening.

In our very modern equipped commercial hardening shop, in which the parts for a couple of thousand inland firms are hardened, the Lindberg furnace has done much to increase our production.



Ministério Da Agricultura Departamento Nacional Da Produçao Mineral Laboratório Da Produçao Mineral, Rio De Janerio, D. F.

Atendendo ao pedido dos representantes no Brasil da Lindberg Engeneering Co., de Chicago, Estados Unidos da America do Norte, declaramos ter em funcionamento, em nossos laboratorios, diversas placas aquecedoras e fornos eletricos, fabricados pela Lindberg.

Todo esse material vem funcionando a inteiro contento de nossos tecnicos.

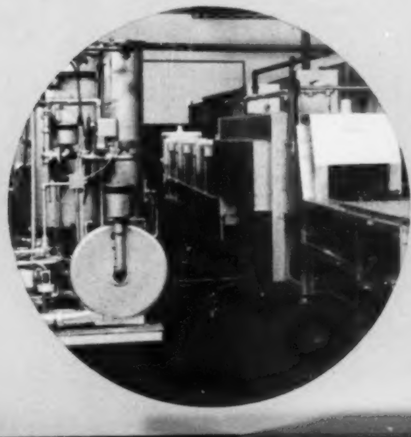
At the request of the representatives in Brazil of the Lindberg Engineering Co., Chicago, U.S.A., we declare that we have in use, at our laboratories several hot plates and electric furnaces manufactured by Lindberg.
All the above material is entirely satisfactory to our technicians.

Fiat, Sezione Automobili, Torino

I nostri forni Lindberg funzionano ottimamente.
Ci é gradita l'occasione per porgerVi i ns/ più distinti saluti.

Our Lindberg Furnaces function perfectly.

On this pleasant occasion we present our distant salutation.



Lindberg in foreign lands

Electric Resistance Furnace Co.
Weybridge, Surrey, England

Electric Furnace Co.
Waybridge, Surrey, England

Etablissements Jean Aube
Paris, France

Gerard Plueger
Antwerp, Belgium, Laboratory Furnaces

Allmet Industries Pty., Ltd.
Sydney, Australia

A. Schuabarth & Co.
Basle, Switzerland

Sabin St. Germain
Mexico, South America

Williams & Wilson
Quebec, Toronto, Montreal, Windsor, Canada

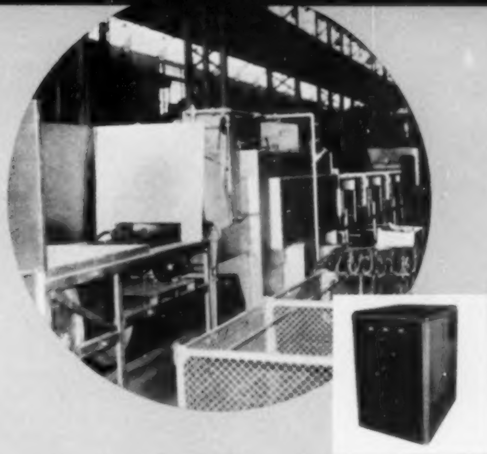
Lindberg Itialana
Milan, Italy

Impresa Progresso
Rio de Janeiro, Brazil, Laboratory Furnaces

Lutz Ferrando y Cia
Buenos Aires, Argentina

Ing. G. W. Berg & Co.
Helsingfors, Finland

Axel Kistner
Stockholm, Sweden



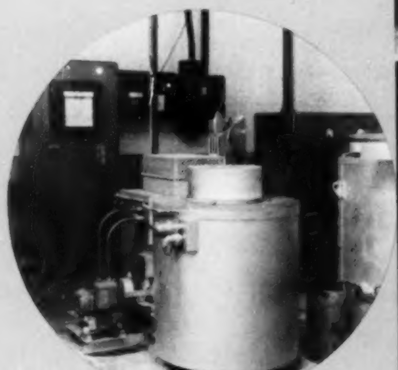
Innocenti, Milano

Abbiamo installato i Vs. forni che funzionano da tempo con ns. completa soddisfazione. Siamo lieti di farVi questa dichiarazione e di segnalarVi che, grazie ali Vs. impianti, abbiamo ottenuto notevoli vantaggi sia nella qualità del prodotto, sia nel costo di produzione.

Vogliate gradire, coi ns. ringraziamenti, i ns. migliori saluti.

We have installed your equipment which functions with complete satisfaction. We are happy to declare and signify our thanks to you and all the employees. We have kept complete books, which prove the advantages and profit and also the quality of the product and the low cost of production.

We thank you very much and send greetings.



La Compagnie Singer, Paris

Les fours Lindberg construits sous licence par les Etablissements Jean Aube & installes dans nos atelires nous donnent entiere satisfaction.

The Lindberg Furnaces built under licence by Jean Aube and installed in our shop give us complete satisfaction.

Ministerio Do Trabalho, Industria E Comercio Instituto Nacional De Tecnologia, Rio de Janeiro, D.F.

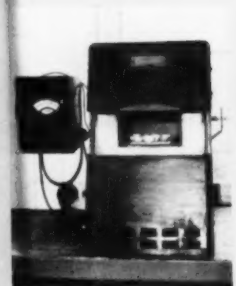
Dentre a aparelhagem de aquecimento existente na Divisão de Indústrias Metalúrgicas, ocupam lugar proeminente, as placas aquecedoras H-2 e os fornos CR-5, CF-1, B-2 e G-10, tôdos de fabricação de Lindberg Engineering Co.

O uso constante que vem fazendo esta Divisão, há mais de cinco anos, de tais equipamentos com absoluto sucesso quanto à perfeição de funcionamento, atesta eloquentemente a alta qualidade de sua fabricação, que não despreza aliás as linhas estéticas, bem características das placas aquecedoras e dos fornos Lindberg.

Amongst the heating apparatus existent at the Metallurgical Industries Division, the hot plates H-2 and the furnaces CR-5, CF-1, B-2 and G-10, all manufactured by the Lindberg Engineering Co., occupy a prominent place.

The constant use that this Division is making of such equipment, for over five years, with absolute success as to the perfect functioning, attest eloquently the high quality of its manufacture, and maintain the esthetic lines, which is quite characteristic of the Lindberg hot plates and furnaces.

Lindberg Melting Furnaces, including the two-chamber aluminum induction furnace illustrated here, are built in England by the Electric Furnace Co. Lindberg Heat Treating Furnaces are built by the Electric Resistance Furnace Co. both of Weybridge, Surrey.



Société Anonyme John Cockerill Seraing (Belique)

Veuillez noter que les fours Lindberg qui sont en service en nos usines d'Athus, nous donnent satisfaction.

Agréez, Messieurs, nos salutations distinguees.

You'll kindly note the Lindberg furnaces that are in service in our shops at Athus (Belgium) are giving us satisfaction.

Lindberg manufactures a complete line of industrial furnaces

Cyclone Tempering Furnaces
Super Cyclone High Temperature Convenction Furnaces
Atmosphere Heat Treating Furnaces
Atmosphere Brazing and Sintering Furnaces
Atmosphere Generators

Melting Furnaces, Gas, Oil, and Electric
Two-Chamber Induction Melting Furnaces
High Frequency Induction Heating Units
High Frequency Carbon Determinator Units
Laboratory Furnaces and Equipment

LINDBERG FURNACES

Lindberg Engineering Company, 2450 W. Hubbard Street, Chicago 12, Illinois

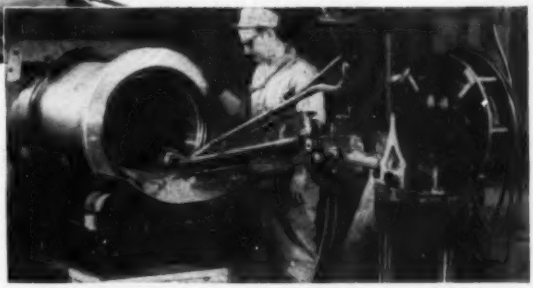
A Day's Output Every Hour

with UNIONMELT Welding

Trade-Mark

(*Above*) UNIONMELT welding a chromium alloy end ring to a mild steel pump shell takes only 1 hour and 23 minutes. Former methods of welding took 10 hours. Ring and shell, each 4 in. thick, are joined in consecutive passes as the work rotates under the UNIONMELT welding head.

(*Right*) This UNIONMELT welding machine smoothly deposits a sound, corrosion-resistant overlay inside a mild steel pump shell. Stainless steel metal — 20 to 120 lb. of it, depending on pump size — builds up at 20 lb. per hour. Highest former rate was 2 lb. per hour.



In making high-pressure steam pumps, these two welding operations used to take 20 hours—2½ working days. This was cut to 2½ hours by UNIONMELT welding as shown above. In addition, finishing costs dropped sharply because the UNIONMELT deposits are smoother and need less machining.

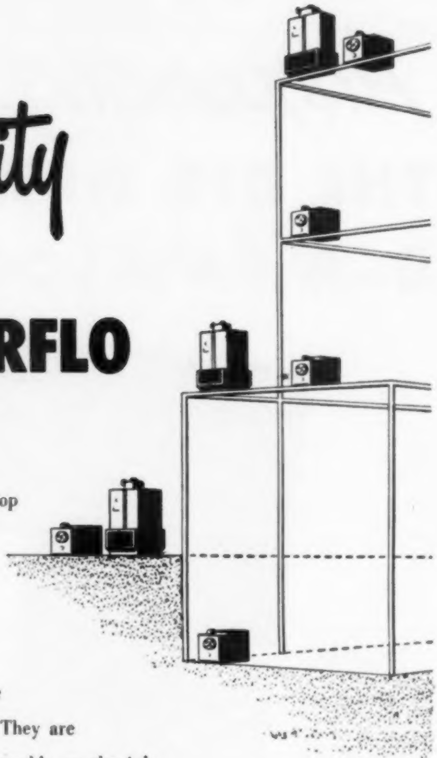
High-speed production is common wherever automatic UNIONMELT welding is used to join ferrous or non-ferrous metals. Welds up to 3 in. thick can be made in one pass; light-gage sheet can be welded at speeds up to 200 in. per minute.

UNIONMELT welding is only one of many time- and moneysaving LINDE methods for making, cutting, joining, treating, and forming metals. So, whatever you do with metals, there is a good chance that LINDE know-how, show-how, and equipment can help you do it better, more quickly, or at lower cost. Telephone or write to our nearest office today. LINDE AIR PRODUCTS COMPANY, a Division of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in Other Principal Cities. In Canada: Dominion Oxygen Company, Limited, Toronto.

Unionmelt
Trade-Mark

EQUIPMENT AND SUPPLIES
for fast, automatic electric welding.
No sparks, spatter, smoke, or flash.

any location any capacity



Just name the place . . . and

AQUATOWER or VAIRFLO

will do the water cooling job!

Indoors or out . . . on the ground or on the roof . . . on the top floor or in the basement—*there's a Marley cooling tower designed to fit any location and any cooling requirement.*

If your job is in the 3-ton to 60-ton range, you need an adaptable Aquatower—the compact, trouble-free cooling tower for indoor or outdoor use. Aquatowers are made in nine sizes and two styles to do each specific job economically. They are shipped completely assembled or "knocked-down" for easy assembly on the job.

In larger capacity installations the answer is a versatile Marley Vairflo . . . a broad range cooling tower with all the quality "extras" ordinarily found only in heavy-duty, high priced towers. The Vairflo, in steel or wood, harmonizes with architectural design. All material in Vairflos is completely prefabricated for simple job erection.

Whatever your need, select a Marley tower backed by the Marley guarantee and the "know-how" gained in more than 25 years of leadership in the water cooling industry. For more information, write for Marley bulletins AQ-51 and V-51, or call the Marley representative in your city.

also producers of

DOUBLE-FLOW TOWERS
CONVENTIONAL TOWERS
DRICOOLERS
NATURAL DRAFT TOWERS
SPRAY NOZZLES

The Marley Company, Inc. MARLEY

KANSAS CITY 15, KANSAS


COSTS DOWN 25%
PRODUCTION UP 100%
WHEN STRESSPROOF® REPLACED HEAT-TREATED .40 CARBON ALLOY STEEL BARS
• Speeded Machining 50% to 100%
• Eliminated need for Heat Treated Alloy Bars
In this asphalt road layer, instead of using a heat-treated, hot-rolled .40 carbon alloy bar, STRESSPROOF was specified. STRESSPROOF provided in-the-bar the necessary strength and wear resistance, and machined so much easier that production time was cut in half.
STRESSPROOF's unique combination of four important qualities in-the-bar is cutting costs and speeding production on many similar defense jobs. STRESSPROOF is twice as strong as ordinary cold-finished bars. Its resistance to wear often makes carburizing unnecessary. It is stress-relieved to minimize distortion, and has in-the-bar machinability fully 50% better than heat-treated alloys of the same hardness. Yet STRESSPROOF is less expensive than all cold-finished and most hot-rolled alloy steel bars that have been fully heat treated.
STRESSPROOF is also available with a Ground and Polished finish.
LASALLE STEEL CO.
1424 150th Street, Hammond, Indiana
Manufacturers of the Most Complete Line of Cold-Finished and Ground and Polished Bars in America
La Salle
STRESSPROOF
STRESSPROOF IS PLAYING A VITAL ROLE IN NATIONAL DEFENSE!
A very large proportion of STRESSPROOF production, today, is going into defense jobs. However, from time to time sample bars may be available for testing purposes.

RIEHLE

SCREW POWER UNIVERSAL TESTING MACHINES *with*

5 SCALE RANGES

PRECISE LOAD INDICATION FOR ALL YOUR TESTS

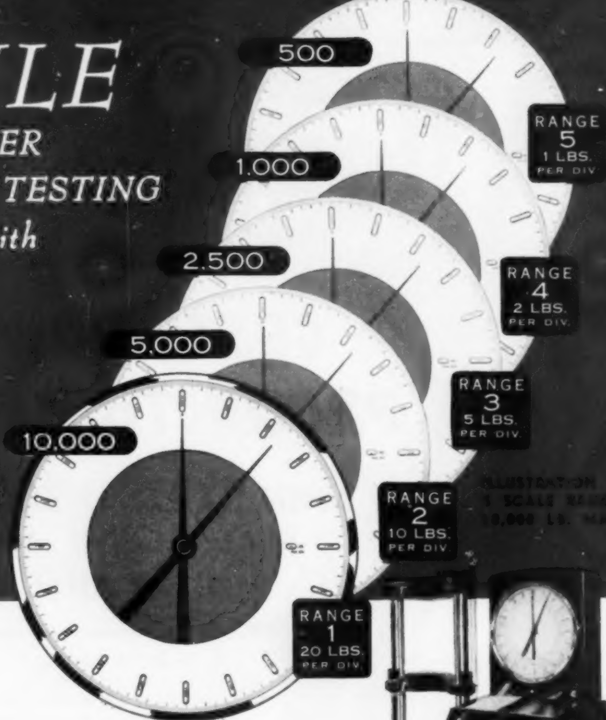


ILLUSTRATION SHOWS 5 SCALE RANGES ON 10,000 LB. MACHINE

BUILT IN 11 SIZES

2,000 LBS.	30,000 LBS.	160,000 LBS.
5,000 LBS.	60,000 LBS.	200,000 LBS.
10,000 LBS.	120,000 LBS.	300,000 LBS.
20,000 LBS.		400,000 LBS.

Only Riehle gives you 5 separate ranges in every Screw Power Universal Testing Machine . . . the equivalent of 5 complete machines in 1.

5 scale ranges give you precise coverage over the machine's full capacity and permit you, by a turn of the range selector knob, to choose the range most applicable for any given test.

ACCURATE-CONVENIENT-DEPENDABLE

Other Riehle features you'll like are the fool-proof Pendomatic Indicating Unit . . . accuracy guaranteed within 1/2 the normal tolerance allowed by ASTM and Federal specifications . . . exceptionally low weighing table . . . low over-all height . . . easy installation and distinctive streamlined appearance.

NEW ILLUSTRATED CATALOG

Send today for 28-page catalog, covering all Riehle Screw Power Universals. Contains illustrations, features, operating details, specifications.

"ONE TEST IS WORTH A THOUSAND EXPERT OPINIONS"

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AMERICAN MACHINE AND METALS, INC.

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Engineering Digest

OF NEW PRODUCTS

FURNACE LOADER: A new mechanical furnace loader developed by A. D. Alpine, Inc., speeds loading and unloading operations in heat treatment by eliminating single piece handling. All work to be treated is placed on the frame of the loader, which will handle several layers of work at one time, and the entire load picked up and inserted into the furnace by the fork bars of the loader.

Similarly, unloading is accomplished by simply inserting the fork bars and withdrawing the load from the furnace. The entire load is then wheeled to the quench tank or the next operation, and by hydraulic release quenched or placed at any desired level. During the entire operation, the operator is protected from heat by a built-in metal shield.
For further information circle No. 401 on literature request card on p. 32B

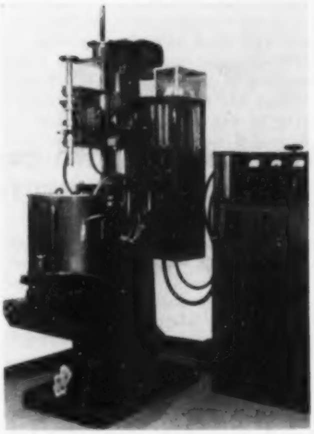
CIRCLE SHEAR AND FLANGER: The Niagara Machine & Tool Works has just announced a new high-speed circle shear and flanger, especially designed for high production of discs and heads at minimum tool investment. It is of interest particularly to manufacturers of tanks, drums, boilers, hot water heaters, containers, metal furniture and many other sheet metal products. As a circle shear it cuts at high speed circular discs or circular arcs of sheet metal up to 8-gage mild steel or 12-gage stainless steel. Discs from 8 to 58 in. in diameter are produced from square blanks. Discs as large as 75½ in. in diameter can be cut from octagonal blanks. As a flanger it turns at high speed smooth, high flanges up to 1½ in. deep from circular discs. Head diameters ranging from 18½ to 73½ in. are flanged with ease.
For further information circle No. 402 on literature request card on p. 32B

MACHINING SINTERED CARBIDES AND SUPERALLOYS: A completely new method of metal removal by direct utilization of electrical energy for machining any electrically conductive material has been developed. In the new process, known as Method X, metal is removed in a directed manner by means of an electric spark discharge which does not otherwise affect the work material's physical or chemical characteristics. The process is made available through the Method X Corp., an affiliate of the Firth Sterling Steel & Carbide Corp.

The machining action depends on a mechanical, not thermal, effect of electricity which sets up internal mechanical stresses by the use of extremely high current densities and thereby causes the metal particles to detach themselves from the work material without melting. Surface finishes of 26 micro-in. can be obtained. Lapping of less than 0.001 in. will produce any desired finish down to 0.15 micro-in. on sintered carbide. Center-to-center spacing of holes through the same workpiece can be controlled to approximately 0.0005 in. Blind hole fillet radii can be made as small as 0.002 in.

An example of application is for gas turbine blading. Blade root mounting serrations are being laboriously ground for the intricate shapes required and to extremely close tolerances. Blade sections are shaped by contour milling, precision casting or hammer forging. All processes are slow and expensive.

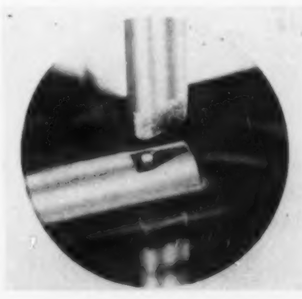
Die sections of sintered carbides are generally fastened by means of threaded steel sections brazed into the carbide and secured to the backing blocks by screws. Another means of



fastening die sections is to shape, drill and tap wedges to fix the carbide die sections to backing blocks. Both methods are slow and costly and not entirely satisfactory.

Gas turbine blade contours and root serrations can be readily shaped with Method X. Hardness has no effect on machinery speed. Sintered carbide die sections can be bored and tapped so that direct fastening to the backing blocks with machine screws can be accomplished. Complicated geometric shapes can be shaped directly into the hardest of metals.

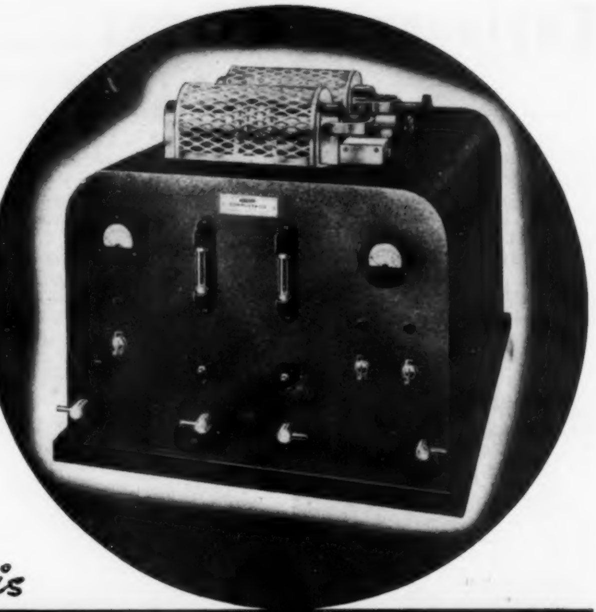
The problem of warpage encountered in heat treating steel dies composed of symmetrical hole shapes as in dies for electrical stator laminations can be eliminated completely by first heat treating the solid steel section and then machining the desired shapes by Method X.



The equivalent of all machining operations such as boring, drilling, tapping, internal and external shaping, engraving with a shaped electrode or by using the electrode as a cutting tool can be done expediently with Method X. In addition, some machining operations can be performed that are not practical even

TWO TUBES . . . TWO CIRCUITS
COMBUSTRON MODEL 120

by **BURRELL**



For carbon analysis in ferrous metals

COMBUSTRON

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Loading is horizontal for greatest flexibility. Combustion boats may be used for a great variety of samples ranging from coarse to fine meshes and low to high carbon content including alloy steel, cast iron and stainless steel. And—for analysis of low carbon steels, each Burrell combustion boat will take up to a full factor weight of coarse drillings.

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with ordinary machinable materials on conventional machines. For example, a blind triangular shape, open at the apex and having an integral pin located in the center of the triangle, is formed by the use of an electrode made to the shape desired and fed directly into the workpiece by the Method X machine.

The machine's design is similar to a drill press with a pedestal-type base, an electrode feed and control mechanism, and a remote unit power supply fed from 220-volt, 60-cycle, single-phase lines. The peak demand under the most severe cutting conditions does not exceed 7 kw. A dielectric fluid such as fuel oil, kerosene or a compound especially developed for this purpose, Dielectro X, is used to enclose the cutting operation. The purpose of the work submersion in the Dielectro fluid is to build up electrical resistance so that the energy storage devices in the machine may be fully charged prior to discharge. Secondly, to flush the loosened particles from the work area.

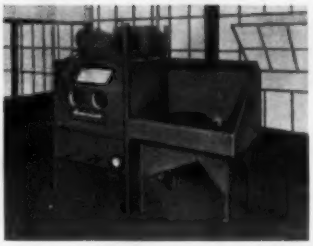
Electrodes are made of a highly conductive, easily machined material such as brass, although other conducting materials may be used. They are usually machined to a negative of the shape to be produced when the machining operation can be performed with the head moving in a vertical direction.

For further information circle No. 403 on literature request card on p. 32B

STEAM-JET CLEANER: Livingstone Engineering Co. announces a new steam-jet cleaner Model JC-25. Heretofore, steam-jet cleaning has been found effective at steam pressures in the range from 125 to 145 psi., but field and laboratory tests have shown that faster cleaning can be obtained by stepping up the velocity of the jet without adding appreciably to the electric power requirements. The JC-25 is built to operate at pressures up to 200 psi. The combination of this high pressure and a new lance gives more powerful cleaning action. The JC-25 uses steam from a built-in high-pressure boiler. Small quantities of solvents are used effectively and economically. Rated at 20 kw., the JC-25 under ordinary operating conditions consumes 15 kw. per hr.

For further information circle No. 404 on literature request card on p. 32B

WET BLAST MACHINE: The introduction of a new wet blast machine, the Liquamatte, is announced by American Wheelabrator & Equipment Corp. Among the special features in



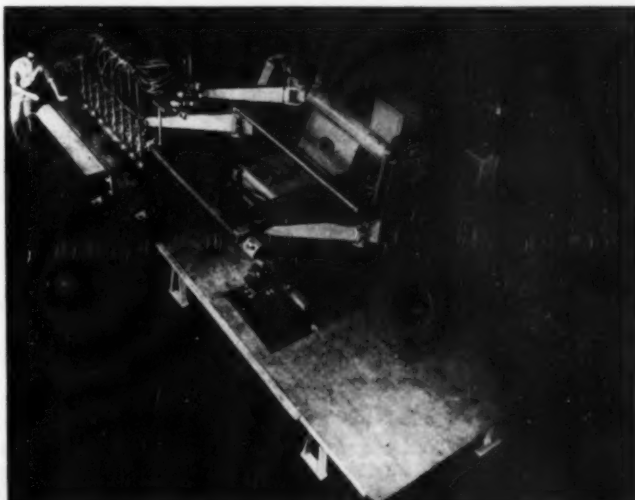
the new wet blaster is a vertical pump for slurry recirculation. It is adaptable to rugged service, and because of its position, it eliminates all suction piping, valves, fittings, and labor for removing them for inspection of the pump. It is always primed by flooded-type suction, and the operation of valves for starting or stopping is unnecessary. Loss of slurry through leakage is eliminated because there are no packing glands. Abrasive can't plug the pump impeller when the machine is shut down. Another important feature is that the hopper need not be drained before the pump is removed. Rubber hose has been used instead of metal pipe wherever possible. A reset timer is available which tells at a glance the number of blasting hours that the abrasive has been in the machine. It lets the operator know when to change abrasive and makes it easier for him to avoid wasting abrasive. The machine is intended to perform work for which dry blasting is too severe; namely, work with thin edges and sharp corners or work needing precision cleaning. Abrasive sizes stocked range from 80 to 2500 mesh.

For further information circle No. 405 on literature request card on p. 32B

TRAVELING HEAD GRINDER: A new approach to the problem of face grinding is offered in the Series E-20 traveling head grinder, developed and built by Mercury Engineering Corp. Designed for the grinding of armor plate, it offers new opportunities in grinding edges, angular surfaces, compounds and bevels, as well as machin-

GAS CUTTING MACHINE: Air Reduction Sales Co. has announced the Airco No. 50 Travograph, the latest addition to its line of gas cutting machines. Guided by manual, magnetic or electronic tracer, this pantograph-type machine will cut an unlimited variety of shapes from steel plates, slabs, billets and forgings and makes equally practicable and economical the cutting of either one or a few parts or identical parts on a quantity production basis. The rigid rail assembly, made of specially rolled tracks with accurately machined surfaces, provides a smooth runway for the carriage. Guide rollers on the carriage base keep the carriage on a true, vibration-free course. Flame hardened carriage wheels insure long service life. Torch holders are easily moved.

For further information circle No. 406 on literature request card on p. 32B



Overcome Steel Shortage Reduce Costs

Fig. 1
Meehanite Plate Bending Rolls

The two Meehanite rolls shown, Fig. 1, have replaced forged rolls in a pyramid plate bending unit, Fig. 2. This is believed to be the first such installation.

Overall length of each roll is 14½ ft., diameter 13 inches. The rolls handle plate thicknesses up to 1¼ inches and 48 inches wide, imposing extremely unusual stresses on the journals and requiring high resistance to fatigue. They have been in daily service for over 18 months providing the toughness, strength and rigidity needed for this application.

Hardness and tensile tests were made from a 15" diameter riser used in pouring the casting, Fig. 3. Reading – 241 Brinell across *entire* diameter; Tensile Strength 47,000 psi.

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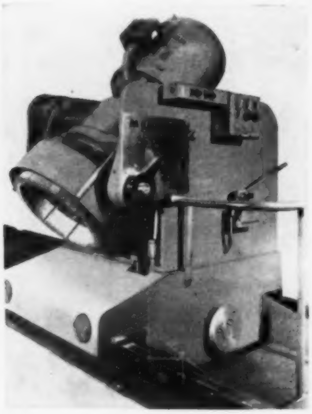
ing pads on heavy castings 20 ft. or longer. This grinder runs on self-powered precision rollers along rails machined to precision tolerances and equipped with built-in leveling devices.



The E-20, employing a 20-in. face-type grinding wheel mounted on a head which tilts from horizontal to full vertical, has complete mobility with traverse rate continuously variable. Two or more grinders can operate simultaneously on a single set of rails.

For further information circle No. 407 on literature request card on p. 32B

PORTABLE ELECTRIC OVEN: Announcement has been made by Grieve-Hendry Co. of a new low-priced portable electric oven, for processing at temperatures such as required for stress relief of springs and plated parts. Construction permits the nesting of one oven on top of another.

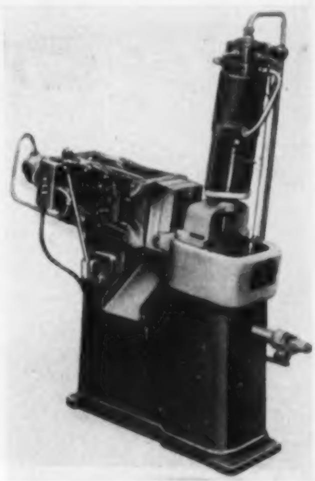
They can be used in groups or banks and can be operated individually, or selected ovens in the group can be cut out or heated at different temperatures. Temperature range is 100 to 800° F. Construction is heavy gage steel with Fibreglass insulation. It will operate from any 110-volt outlet. No special wiring is required. 220-volt units are available. Thermostat, outside reading thermometer and pilot light are standard equipment. Size is 30 in. wide by 25 in. deep by 24 in. high, outside.

For further information circle No. 408 on literature request card on p. 32B

STABILIZER FOR LOW-HYDROGEN ELECTRODES: With the rapidly increasing use of the "low hydrogen" welding process, it has become necessary to find some means of protecting the electrodes from atmospheric moisture from the time they are removed from the moisture-proof container until they are put into use. A compact moisture-content stabilizer has been introduced by Fred C. Archer, Inc., which provides the desired protection of low-hydrogen welding rods at point of use. The unit stores 400 lb. of electrodes and, because of its size and design, may be located at any point convenient to the welding operation.

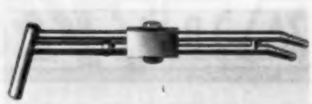
For further information circle No. 409 on literature request card on p. 32B

DIE-CASTING: A new 1-lb. die-casting machine, announced by DCMT Sales Corp., operates on a standard 80-psi. air line and consumes only 0.55 cu.ft. of free air per cycle of operation. Some of the specifications are as follows: pressure on metal with



1½-in. diameter plunger, 1620 lb.; die opening, 4 in.; casting capacity, 12 oz.; maximum area of casting, 12 sq.in.; standard diameter of plunger,

1⅛ in.; pot capacity, 45 lb. of zinc; floor space, 30 by 12 in.; weight (net), 450 lb.
For further information circle No. 410 on literature request card on p. 32B

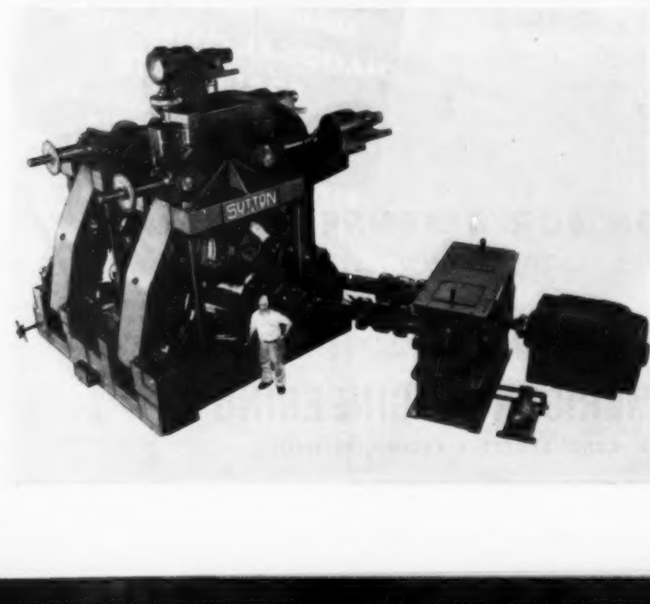


CUTTING TOOLS: The new line of Superweld tools available from A. Milne & Co. features solid high speed steel heads of section equal to the tool shanks, joined to the shanks by electrical butt-welding. The heads are made of high speed steel containing 21% tungsten and 13% cobalt and are fully heat treated to give maximum cutting efficiency. The shanks are of medium carbon steel. The tools, as supplied, are ready to use; no forging or hardening is required.
For further information circle No. 411 on literature request card on p. 32B

TORCH: A built-in thumb control regulates gas and air volume on the new precision soldering-brazing torch manufactured by Mass Co. The new torch works successfully either as a production tool or as a portable torch, for radiator, electrical and sheet metal work; also silver soldering, light brazing and hardening drills and drill bushings. The torch is 11⅛ in. long and weighs approximately 10 oz.
For further information circle No. 412 on literature request card on p. 32B

PHOSPHATE TREATING COMPOUND: A new phosphate compound for treating metallic parts is being produced by Octagon Process, Inc. It meets the specification for a Class C (Type II) finish in U. S. Army Spec. No. 57-O-2C and also JAN-C-490, Grade 1.
For further information circle No. 413 on literature request card on p. 32B

TUBE AND BAR STRAIGHTENER: The 5 M KTC bar and tube straightener by Sutton Engineering Co. is used for straightening tubes from 4½ to 16½ in. o.d. and solid bars from 4½ to 9 in. diameter. The design employs a total of seven straightening rolls. One group of three rolls is mounted at the entry end of the machine and another group of three at the delivery end. Each roll group is composed of one large driven roll and two idler rolls disposed at an angle of approximately 120° to each other. Located between the two 3-roll groups is a middle idler roll which serves the purpose of deflecting the pipe during the straightening operation. This roll arrangement eliminates the use of all guides and at the same time positively confines the bar or tube to the pass line throughout the straightening operation. An outstanding feature of the KTC straightener is the automatic roll angling device. To change from straightening 5 in. to 14 in. tubes requires less than 2 min. Speeds vary from 60 to 240 ft. per min. using a 200-hp., 300 to 1200 rpm. adjustable speed d-c motor.
For further information circle No. 414 on literature request card on p. 32B



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Field-tested for over 2 years, "RADIVECTION" is an advanced heat treating furnace design incorporating both radiant and convection methods of heating.

The furnace load is preheated by radiation. This speeds *initial* heating, thereby shortening the cycle and increasing production.

Simultaneously, additional heat is transferred to the work by means of high velocity, pressure blower convection. 100% penetration of the work insures minimum temperature differential between top and bottom of the load *during* heating, and maintains uniformity at control temperature. This results in work of higher quality and minimizes the possibility of rejects caused by scale or distortion.

In the gas fired "RADIVECTION" furnace, radiation and convection methods of heating are combined to such advantage that field tests prove 75% thermal efficiency at 1000° F. The increased production poundage obtained, per unit of fuel, results in both fuel conservation and lower fuel costs.

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What's New

IN MANUFACTURERS' LITERATURE

415. Abrasive Belts
New catalog and basic manual on abrasive belt machines. Complete descriptions of each machine, as well as comprehensive data on a machining process especially adaptable to defense production. *Porter-Cable Machine Co.*

416. Abrasives, Coated
Six case histories on hand finishing operations for various parts and tools. *Behr-Manning Div.*

417. Alloy Brazing
New bulletin 20 covers silver alloy brazing with Easy-Flo and Silfos. Tells where and how to use these alloys to the best advantage. Shows many interesting applications; describes fast brazing techniques. *Handy & Harman.*

418. Alloy Steel
Booklet on Carilloy steel tells how No. 4150 and others provide toughness, strength and light-weight durability under trying conditions of service. *U. S. Steel Co.*

419. Alloy Steels
New 16-page, pocket-size booklet entitled "Republic Alloy Steels and How to Get the Most Out of Them" contains seven case histories selected from widely varied fields to demonstrate the versatility of alloy steels. *Republic Steel Corp.*

420. Alloys, Fabricated
Catalog available showing cost-cutting fabricated heat treating equipment for higher payloads and better quality. *Rolock, Inc.*

421. Alloys, Nickel
Hastelloy nickel-base alloys are available for fabricating corrosion-resistant screen, cloth and baskets. Also for metal spraying many types of automatic welding and hard-facing. Booklet, "Hastelloy Nickel-Base Alloys", gives full details. *Haynes Stellite Co.*

422. Aluminum
Copy of "Alcoa Aluminum Impact Extrusions" will be sent on request, giving full information on impact extrusion process and service. Shows whole range of shapes for engineering. *Aluminum Co. of America.*

423. Aluminum
16-page, 3-color booklet entitled, "Welcome to Jones Mills" shows how this plant produces aluminum pig by the electrolytic reduction process. *Reynolds Metals Co.*

424. Aluminum Castings
New 4-page two-color bulletin No. 20A describes facilities and methods for producing aluminum castings. *Aluminum Industries, Inc.*

425. Aluminum Forgings
To help you in designing for aluminum forgings, a new book is offered, covering relation of forging design to die sinking and relation of forging design to the manufacturing process. Also a section on metallurgy gives all commercial alloy compositions, physical properties and tolerances. *Aluminum Co. of America.*

426. Aluminum Welding
New control system, that extends electrode life for spot welding aluminum, fully described in "Technical Advisor No. 15". *Reynolds Metals Co.*

427. Barrel Finishing
55-page book on barrel finishing with Alundum tumbling abrasive. Procedures, practical operating suggestions, and characteristics of abrasive. *Norton Co.*

428. Belt, Abrasive
4-page, illustrated bulletin describes advantages of new "61" contact wheel. Time charts show how new, specially designed rubber wheel provides longer belt life and increased cutting rate. *Carborundum Co.*

429. Belts, Metal
Bulletin 47P illustrates and describes complete line of wire belts for industry. *Ashworth Brothers, Inc.*

430. Bending
32-page illustrated manual describes procedures for bending a wide variety of shapes from tubing, angles, channels, extrusions and other solid forms. *O'Neil-Irwin Mfg. Co.*

431. Beryllium Copper
Helpful engineering information contained in new monthly series of Beryllium copper technical bulletins. *Beryllium Corp.*

432. Bimetal Elements
64-page catalog written especially to help the design and product engineer select the type and size of thermostatic bimetal element best suited to his temperature-responsive device. *W. M. Chace Co.*

433. Blast Cleaning
Bulletin 32-B contains photographs and complete descriptions of AG blast cleaning cabinets for all types of industrial applications. *Ruemelin Mfg. Co.*

434. Bottom Boards, Magnesium
Complete information and price schedule on magnesium bottom boards for maintaining high quality castings and mold stability. Available from stock in 74 standard sizes. *Christiansen Corp.*

435. Brass and Bronze
8-page illustrated booklet on control methods as applied to brass and brass rod, forgings, die castings and welding. *Titan Metal Mfg. Co.*

436. Brazing Alloys
Standard pricing schedule and torch brazing instructions for silver brazing alloys listed in 4-page leaflet. *American Platinum Works.*

437. Brinell Tester
8-page bulletin on a portable Brinell hardness tester, employing 2.5, 5.0 and 10.0 mm. balls and loads from 187.5 to 1000 kg. *R. Y. Ferner Co., Inc.*

438. Bronze Alloys
New folder giving tables of properties (hardness, tensile, fabrication, physical) as well as uses and forms and other data on Chase phosphor bronzes. *Chase Brass & Copper Co.*

439. Bronz Castings
Paper on effects of superheating, 85-5-5-5, 88-8-4 and 80-10-10 alloys, with tables and graphs showing physical property changes. *R. Lavin & Sons, Inc.*

440. Camera, High Speed
"Magnifying Time", a new folder describing high-speed camera capable of 1000 to 3000 pictures per second. Particularly adaptable for close inspection in machine tool operations and also for measuring flow of liquids as in chemical mixers, coolant flow, etc. *Eastman Kodak Co.*

441. Carbides
20-page "Aid to Carbide Users", in color, includes sections on standard and modified blank styles, solid ground cylinders, rectangular strips, standard bushings and solid carbide inserts. Catalog also features a grade selection guide. *Adamas Carbide Corp.*

442. Carbon Control
Catalog T-623 describes the Microcarb control system that continuously measures the active carbon in the furnace atmosphere during heat treatment. *Leeds & Northrup Co.*

443. Carburizing
Interesting Char booklet tells how activated particles of Char are coated with a heavy shell of carbon, adding to mechanical strength and providing a protective coating. *Char Products Co.*

444. Castings
Bulletin FC-350 outlines the many advantages of improved Fahrite corrosion-resistant castings. *Ohio Steel Foundry Co.*

445. Castings, Steel
New bulletin describes Pyrasteel, the chromium-nickel-silicon alloy for resisting oxidation and corrosion up to 2000°F and for withstanding most concentrated or dilute commercial acids and corrosive gases. *Chicago Steel Foundry Co.*

446. Cast Iron
48-page book, profusely illustrated, showing a wide range of light and medium castings produced in gray, alloyed and inoculated irons. *Hamilton Foundry & Machine Co.*

447. Cast Iron
4-page booklet providing case histories of unusual applications of Meehanite castings in various industries. *Meehanite Metal Corp.*

What's New

IN MANUFACTURERS' LITERATURE

448. Cast Monel

New bulletin contains valuable information concerning production of cast Monel and wide range of desirable physical and mechanical properties obtainable. *Cooper Alloy Foundry Co.*

449. Cleaning and Buffing

Bulletin 44 contains an interesting discussion of barrel deburring, as well as methods of removing many kinds of burrs from sawing, drilling, milling and stamping operations. *Magnus Chemical Co.*

450. Cleaning and Finishing

Attractive 12-page, well-illustrated catalog A-652 gives the complete story on planning industrial finishing systems and shows many actual installations of cleaning and pickling machines operating in large metalworking plants. *R. C. Mahon Co.*

451. Cleaning Brushes

New booklet shows 12 actual case histories of how they provide thorough cleaning of welds, stainless sheet, hot cast iron, automotive parts, brass fixtures, and others. *Pittsburgh Plate Glass Co., Brush Div.*

452. Coatings, Metal

Explanations of high-vacuum evaporation of metals and other solids set forth in detail in new 12-page booklet, "Vaporized Metal Coatings by High Vacuum". *Distillation Products, Inc.*

453. Coatings and Packaging

New 43-page working data file provides valuable guide to better preservation and packaging with three sections on coatings, melting equipment and methods and processing procedures for "hot dip" packaging. *Seal-Peel, Inc.*

454. Coatings, Zinc

16-page illustrated booklet discusses the origin of galvanizing, the various zinc coating methods employed today and the advantages of zinc as a protective coating for iron and steel products. *St. Joseph Lead Co.*

455. Control Instrument

Direct reading spectrometer described in bulletin 34 is calibrated and adjusted to the particular analytical need of each user. Analysis of as many as 12 elements read directly and simultaneously from clock dials. *Baird Associates, Inc.*

456. Continuous Sampling Monitor

New descriptive and illustrative tear sheet on electrical device which automatically keeps track of sampling procedure. *General Electric Co.*

457. Coolant-Lubricant

12-page bulletin on new coolant-lubricant for cutting, grinding, drawing and stamping. Includes three case histories and instructions for use. *General Aniline & Film Corp.*

458. Copper Alloy Forgings

12-page booklet provides practical, comparative illustrations on die-pressed copper alloy forgings. Contains tabulation of physical properties of copper and copper alloys suitable for forgings. *The American Brass Co.*

459. Copper Alloy Tubes

An extensively illustrated 32-page brochure, "Life Extension for Condenser Tubes", deals with causes of corrosion and means of combating them, as well as choice of materials for condenser tubes. *Revere Copper & Brass, Inc.*

460. Copper Alloys, Corrosion Resistance

24-page booklet, "Corrosion Resistance of Copper and Copper Alloys", explains the chemical and physical nature of corrosive attack. Includes tabulation indicating relative corrosion resistance of principal types of copper and copper alloys when in contact with 183 different corroding agents. *The American Brass Co.*

461. Corrosion Data

Wall chart of useful corrosion resistance information for several analyses of stainless steel tubing and pipe in contact with various corrodents. Reverse side contains mechanical data on tubing. *Carpenter Steel Co.*

462. Cupola Charging

Second of a series of booklets on better foundry operation entitled, "Tips on Improving Cupola Charging", contains valuable information on obtaining a smoother flow of materials from freight cars to cupolas. *Whiting Corp.*

463. Cutting Oils
4-page folder on control of soluble oil coola
blending and reclaiming. *Bowser, Inc.*

464. Degreaser
12-page illustrated bulletin describing operat
of degreasing equipment and specific application
vapor degreasers, both tank-type and conveyori
Phillips Mfg. Co.

465. Diamond Abrasive
New 4-page folder on Dymo-C, a diam
abrasive prepared especially for lapping and poli
ing carbide drawing and heading dies. Gi
details on specific performance and applicat
advantages. *Elgin National Watch Co.*

466. Die Steel
New literature available on Bethlehem Co
Headed Die Steel for high production in forg
bolts, rivets, screws, and other products at h
speed. *Bethlehem Steel Co.*

467. Electrodes, Hard-Facing
Bulletin announcing completely new line
Wear-Arc hard-facing alloy electrodes. Inclu
full data on typical applications with physi
properties, welding procedure and identificati
Alloy Rods Co.

468. Finishes
New 4-page, two-color bulletin describes
detail the entire line of Iridite finishes for n
ferrous metals. Also includes section ARP proc
chemicals such as bright hardeners for zinc a
cadmium plating and other specialties. *All
Research Products, Inc.*

469. Finishing
Technical bulletin, designed as permanent
folder, describes Aluminux, a new etching co
pound that eliminates cement-like scale format
on tank and coils. *Diversey Corp.*

470. Forging
4-page folder, "Stainless and High Temperat
Forging Alloys and Drop Forging Tolerance Dat
furnishes the answers to questions on forging
carbon, alloy and stainless steels and high temp
ature alloys. *Steel Improvement & Forge Co.*

471. Forging Machines
Bulletins available describing Acme XN Fo
ing Machines, featuring the exclusive toggle l
construction. Specify size in ordering bulle
covering your own plant operation. *Hill-Acme*

472. Furnace Controls
New 28-page condensed catalog 51-1 on turn
and oven controls lists prices and illustrates vari
of instruments such as temperature controlle
recorders and indicators, control valves, e
Minneapolis-Honeywell, Industrial Div.

473. Furnaces
Catalog A-3 illustrates three specially c
structed furnaces for versatile, economical h
treating of small and large tools and a verti
model for drills, reamers, broaches, etc. *Sentry*

474. Furnaces
Literature describing the use of Marshall tubu
furnaces for constant and uniform temperatu
furnished in types suitable to your needs. A
radial brackets in stationary and compensati
types. *Marshall Products Co.*

475. Furnaces
New all-purpose furnace described in bulle
HD-646 may be used for carburizing, nitridi
dry cyaniding, bright annealing and clean hard
ing. *Hevi Duty Electric Co.*

476. Furnaces
Descriptive bulletins on salt pot furnaces i
wide range of sizes for either high or low-press
gas in heat treating small parts with salt b
processes. *Eclipse Fuel Engineering Co.*

477. Gas Cutting Machine
New catalog available on Arco No. 50 Tra
graph gas cutting machine, equipped with th
distinctly different tracing devices—manual, m
netic, or full-automatic Electronic Bloodhound
cut most intricate shapes from only an outl
drawing. *Air Reduction Sales Co.*

478. Graphite Heat Exchange
Reprint available on Graphite Heat Exchang
Made of Karbate impervious graphite, these
changers are used as boilers, coolers, condens
vaporizers and absorbers in handling corros
chemicals and can be ordered in complete s
range. *National Carbon Co.*

479. Hardness Numbers
Pocket-size table of Brinell hardness numbe
incorporating other tabular information of i
portance to the metallurgist, inspector and engin
Steel City Testing Machines, Inc.

480. Heat Control
Bulletin 4257 describes Pyrocon for qui
accurate reading of surface temperatures of mol
revolving rolls, bearings and other materials. A
outlines a wide selection of thermocouples a
extension arms for laboratory service. *Illi
Testing Labs.*

481. Heating for Brazing and Annealing
8-page illustrated bulletin on high speed heat
equipment for brazing, flame annealing, fla
hardening, selective heating, and heating for fo
ing. *Gas Appliance Service, Inc.*

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Reprint available on Graphite Heat Exchangers. Made of Karbate impervious graphite, these exchangers are used as boilers, coolers, condensers, vaporizers and absorbers in handling corrosive chemicals and can be ordered in complete size range. *National Carbon Co.*

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482. Heating Elements, Electric
Bulletin H gives detailed information on AT-type nonmetallic electric heating elements, including tables for a wide variety of sizes available. *Globar Div., Carborundum Co.*

483. Heat Treating
Bulletin 120 tells how Niagara Aero Heat Exchangers provide better heat control in quenching bath, thus protecting physical properties and saving on water and piping equipment. *Niagara Blower Co.*

484. Heat Treating
Catalog 116 contains 72 pages of factual heat treating data for carburizing, cyanide hardening, brazing, austempering, and annealing processes. *Ajax Electric Co.*

485. Heat Treating
New 60-page book, "Houghton Defense Production Data", contains valuable metalworking "know-how" to help with all types of conversion problems. *E. F. Houghton & Co.*

486. Heat Treating
Handy, vest-pocket data book has 72 pages of charts, tables, diagrams and factual data on late steel specifications, heat treatments, etc. *Sunbeam Industrial Furnace Div.*

487. Heat Treating Equipment
Illustrated literature available on Heil impervious graphite "Norcordal" units. *Heil Process Equipment Corp.*

488. Heat Treating Furnaces
Information available on mechanized batch-type controlled atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration work. *Dow Furnace Co.*

489. Helical Springs
2-pager on how to obtain economical assortment of 100 beryllium copper compression springs for development work. *Instrument Specialties Co., Inc.*

490. High Speed Steel
Bulletin SL-2036 describes the new, improved tungsten-molybdenum high-speed steel, made especially abrasion resistant for taps, twist drills, milling cutters, lathe and planer tools. *Firth Sterling Steel & Carbide Corp.*

491. High Temperature
"Inco High Temperature Work Sheet" provides valuable information and suggestions for solving high temperature problems in design and production. *International Nickel Co.*

492. Immersion Heating
New folder N-33-640(1) describes immersion thermocouple and Rayotubes for measuring bath temperatures in installations ranging from a 275-ton open-hearth down to a 1000-lb high-frequency induction furnace. *Leeds & Northrup Co.*

493. Induction Heater
Bulletin 319 describes the Combustron, electronic induction heater in two or one tube model for flexibility in analysis of low to high carbon content in alloy steel, cast iron and stainless steel. *Burrell Corp.*

494. Industrial Polishing
12-page booklet describing modern techniques of industrial polishing and buffing as related to the varied buffs, polishes and plating supplies. *Schaffner Mfg. Co.*

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495. Industrial X-Ray
New catalog on "Industrial X-Ray Accessories" provides complete listing of this equipment, including chemicals, dark-room accessories, filing equipment, processing tanks, dryers and radiation instruments. *Picker X-Ray Corp.*

496. Laboratory Furnaces
Information and bulletins available along with current price lists on complete assortment of Lindberg laboratory furnaces. *Boder Scientific Co.*

497. Load Testing
Bulletin 325 describes new Type P SR-4 tension load cells based on SR-4 bonded resistance wire strain gages for load measurement. Gives specifications for load cells of four capacities between 10,000 and 100,000 pounds. *Baldwin-Lima-Hamilton Corp.*

498. Magnesium
42-page booklet on processing and properties of wrought forms of magnesium. Includes 31 tables. *White Metal Rolling & Stamping Corp.*

499. Metal Analysis
New brochure describes the operation of the ARL Production Control Quantometer which furnishes direct-reading, pen-and-ink records of quantitative spectrochemical analyses with extra copies, quickly and accurately. Up to 20 chemical elements measured simultaneously. *Applied Research Labs.*

500. Metal Cleaner
New booklet, "Buffing Compound Removal Was a Tough Job", gives complete information on latest development in metal cleaning research. *Cowles Chemical Co.*

501. Metal Cleaning
Information on new cleaning process that uses emulsion cleaners, based on petroleum and addition agent 230. This two-phase bath provides unique cleaning in conjunction with a thin displacement film that removes foreign particles. *Northwest Chemical Co.*

502. Metal Cleaning
New booklet entitled "Your Metal Rearmament Products" contains outline of most efficient methods of handling, as well as cleaning, metal products for defense. *Alvey-Ferguson Co.*

503. Metal Coating
Bulletin entitled "How To Obtain A Grade 1 Finish On Steel" furnishes full details on special protective coating required by Government Specification JAN-C-490. *American Chemical Paint Co.*

504. Metal Finishing
New check list available on sixty products and processes for metal finishing, including a new acid addition agent, a cleaning and pickling agent combined, a new complete inhibitor and a new rust preventive compound. *Enthone, Inc.*

505. Metallizing Process
New 20-page bulletin on the Mogul metallizing gun is fully illustrated and tells how this process aids in fighting corrosion, rebuilding worn parts, and reclaiming mis-machined castings. *Metallizing Co. of America.*

506. Micrographic Equipment
6-page bulletin on a universal camera microscope giving plate magnifications from 4 to 3000X. Full details on optics and accessories included. *Oplem Co.*

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Well-illustrated 8-page folder on N-A-X low-alloy steels lists physical properties and test specifications. *Great Lakes Steel Corp.*

534. Steels, Spring
Complete Spring Steel catalog offers 652 sizes of hardened and tempered spring steels, and in addition lists 133 cold-rolled and bright annealed sizes that are usually carried in stock. *Sandvik Steel, Inc.*

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New 20-page booklet gives technical information of a basic nature on super refractories. Text material is supplemented with charts, tables, illustrations and application data. *Carborundum Co., Refractories Div.*

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A bound reprint of N. G. Branson's documental paper "Metal Wall Thickness Measurement from One Side by the Ultrasonic Method" plus an illustrated explanation of Audigage, Model FM SS-5 Thickness Tester. *Branson Instruments, Inc.*

544. Tool Steel
Selector is handy chart featuring general and heat treating data on non-deforming, water hardening, shock-resistant, hot work and high speed tool steels and hollow die steels. *A. Milne & Co.*

545. Tool Steels
Information on Warplis products, stock size and price folders will be sent on request, along with name of nearest distributor. *Pittsburgh Tool Steel Wire Co.*

546. Tool Steels
Full information on uses, compositions and heat treatment of carbon and carbon-vanadium tool steels. *Vanadium-Alloys Steel Co.*

547. Tubing
36-page illustrated catalog on electric welded steel tubing. Six pages of reference tables on tubing. *Nikoh Tube Co.*

548. Wear-Resistant Castings
New descriptive folder gives interesting facts on Colmonoy hard facing alloys, developed to combat different types of wear: abrasion, corrosion, impact, etc. Made in various forms to suit the methods of application. *Wall Colmonoy Corp.*

549. Welding, Scrap
Information available on oxygen-cutting and powder-cutting with Oxweld equipment to rapidly convert any steel or cast iron section into good, usable scrap. *Linde Air Products Co.*

550. Weld Rod, Hard Facing
4-page bulletin on applications for hard surfacing welding electrodes of 13½% manganese-nickel steel. *Stulz-Sickles Co.*

551. Wire Cloth
New manual entitled "Engineers Manual of Wire Cloth Strainer Design" describes selection of the grade of wire cloth and type of metal. *Michigan Wire Cloth Co.*

552. X-Ray Diffraction
Bulletin 304 describes the Hilger X-ray diffraction unit for determining internal strain or distortion, types of alloy formation, grain sizes and effect of heat treatment to establish correct annealing technique. *Jarrell-Ash Co.*

553. Zinc Plating
Newly revised bulletin on the S-B process for producing zinc deposits satin bright to bright in color, and particularly receptive to conversion coatings such as Lusteron, Cronak, Iridite and Anozinc. *Hanson-VanWinkle-Munning Co.*

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36-page illustrated catalog on electric welded steel tubing. Six pages of reference tables on tubing. *Nikoh Tube Co.*

548. Wear-Resistant Castings
New descriptive folder gives interesting facts on Colmonoy hard facing alloys, developed to combat different types of wear: abrasion, corrosion, impact, etc. Made in various forms to suit the methods of application. *Wall Colmonoy Corp.*

549. Welding, Scrap
Information available on oxygen-cutting and powder-cutting with Oxweld equipment to rapidly convert any steel or cast iron section into good, usable scrap. *Linde Air Products Co.*

550. Weld Rod, Hard Facing
4-page bulletin on applications for hard surfacing welding electrodes of 13½% manganese-nickel steel. *Stulz-Sickles Co.*

551. Wire Cloth
New manual entitled "Engineers Manual of Wire Cloth Strainer Design" describes selection of the grade of wire cloth and type of metal. *Michigan Wire Cloth Co.*

552. X-Ray Diffraction
Bulletin 304 describes the Hilger X-ray diffraction unit for determining internal strain or distortion, types of alloy formation, grain sizes and effect of heat treatment to establish correct annealing technique. *Jarrell-Ash Co.*

553. Zinc Plating
Newly revised bulletin on the S-B process for producing zinc deposits satin bright to bright in color, and particularly receptive to conversion coatings such as Lusteron, Cronak, Iridite and Anozinc. *Hanson-VanWinkle-Munning Co.*

[• If mailed from countries outside the United States, proper amount of postage stamps must be affixed for returning card]

METAL PROGRESS
7301 Euclid Avenue, Cleveland 3, Ohio

October, 1951

401	427	453	479	505	531
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Please have literature circled at the left sent to me.

Name ____________________ Title ____________________

Company ____________________

Products Manufactured ____________________

Address ____________________

City and State ____________________

Postcard must be mailed prior to January 1, 1952— Students should write direct to manufacturers.

**write for our new booklet:
"Control—the Key
to Improvement
in Quality Products"**

As many as eight elements in minute quantities of only .002% can now be analyzed accurately in two minutes. That's how fast a complete analysis of a brass or bronze alloy is recorded with the new Quantometer*, a direct reading spectrometer now in use at the Titan mills.

Titan was the first brass mill to adapt and install the Quantometer for the selection of raw materials and for the control of production of brass mill products (rods, shapes, welding rod and wire, forgings and die castings). Because of its great speed and accuracy, the Quantometer represents an outstanding achievement in metallurgical control.

This milestone in industrial development will further insure maximum benefits to our customers' processes where Titan Brass products are used.

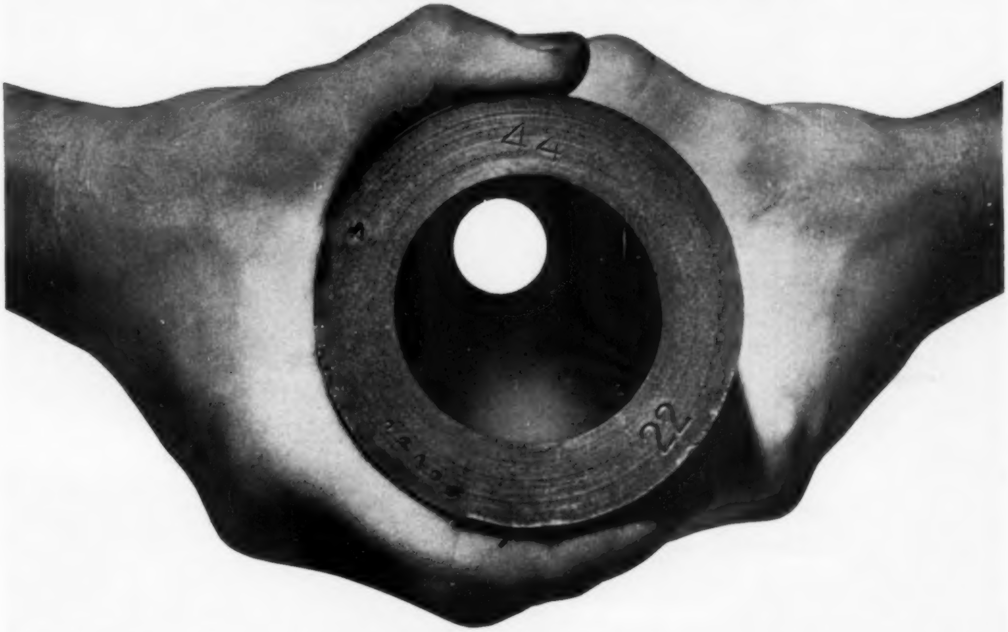
Titan

METAL MANUFACTURING COMPANY
General Offices and Plants: BELLEFONTE, PA.

Offices and Agencies in Principal Cities

Quality Alloys by Brass Specialists | Brass and Bronze Rods • Forgings • Die Castings • Welding Rods

How to add machining capacity without adding machines



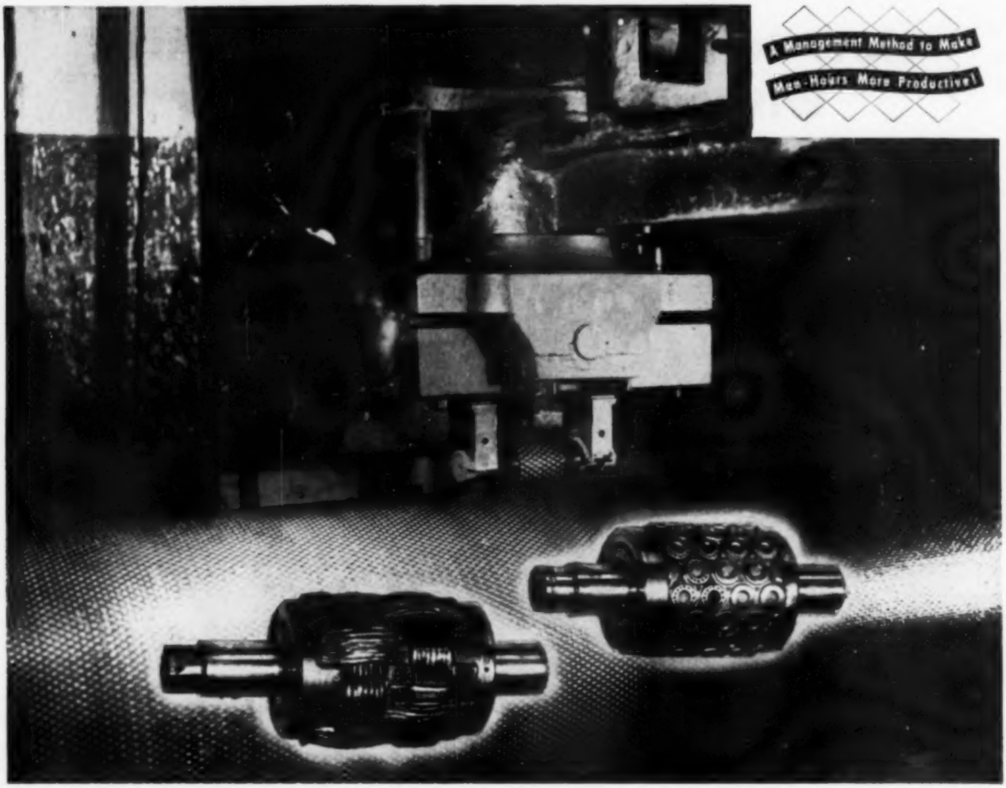
YOUR machine tools become more productive when you use Timken* seamless tubing instead of bar stock for hollow cylindrical parts. Timken tubing has the center hole already there. Drilling is eliminated. Finished boring is often your first production step. As a result, screw machine stations are released for other operations.

You save steel, too, by using seamless tubing. Since the hole is already there, there's less metal that has to be machined away. You get more parts per ton of steel. And to further assure savings in material, the Timken Company provides a tube engineering service which recommends the most economical tube size for your job—*guaranteed* to clean up.

All this and better quality too! Because the piercing process by which Timken seamless tubing is made is basically a forging operation, you have fine forged quality in your product—greater strength and toughness. And from tube to tube and heat to heat, this quality is always uniform. It's rigidly checked at every step in production. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing.



How to Put Delicate Patterns Through a 5-Ton "Wringer", Successfully

These knurling mills, made from No. 11 Special (Water-Hard) Tool Steel, press artistic patterns into large steel rolls for embossing cloth, paper and plastic. Here's what was required of the tool steel: It had to be hard enough to prevent upsetting; tough enough to prevent delicate edges from breaking under operating pressures up to 5 tons. Patterns on the mills were quite fragile and sections as deep as $\frac{1}{16}$" could not collapse. Further, the steel had to heat treat with very little warpage.

But picking the proper steel wasn't as tough as you may imagine. For the Carpenter Matched Set Method not only indicated the one *best* steel for the job but enabled production management to "call its shots" . . . have the mills produce the required number of patterns on schedule, with less costly downtime.

For any plant making or using tools and dies, the Matched Set Method offers even more advantages than simplified selection. You benefit from lower tool steel inventories, heat treating economies, simplified toolroom and production procedures. To discover how it can work for you in your plant, write for the new booklet "How to Get Better Tool and Die Performance". THE CARPENTER STEEL CO., 133 W. Bern St., Reading, Pa.

Export Department:
The Carpenter Steel Company, Reading, Pa. "CARSTEELCO"

Carpenter

MATCHED TOOL & DIE STEELS

More than top-grade steels . . . a Method to keep tooling and production on schedule!

For your convenience, Carpenter carries warehouse stocks in principal cities throughout the country

"ROCKWELL"* HARDNESS TESTERS

See them in Action!

at the

METAL SHOW in DETROIT

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October 15 to 19

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BOOTH A-342

TUKON TESTER
for
MICROHARDNESS TESTING

See how easy it is to be sure of the hardness of metals you process—by using WILSON Hardness Testing equipment

*TRADE MARK REGISTERED

ACCO

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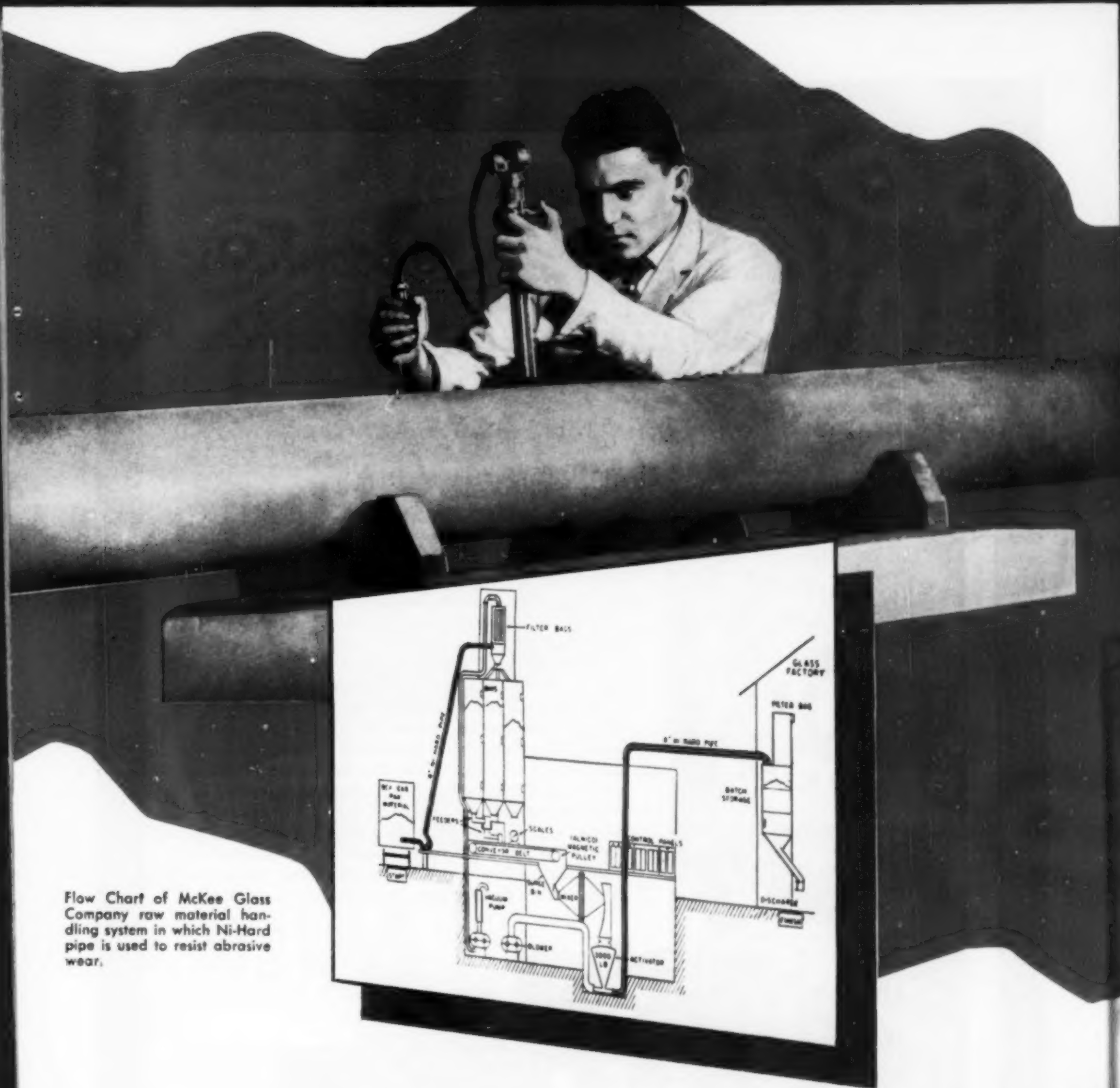
MECHANICAL INSTRUMENT DIVISION
AMERICAN CHAIN & CABLE

230-F Park Avenue, New York 17, N. Y.

TRADE MARK

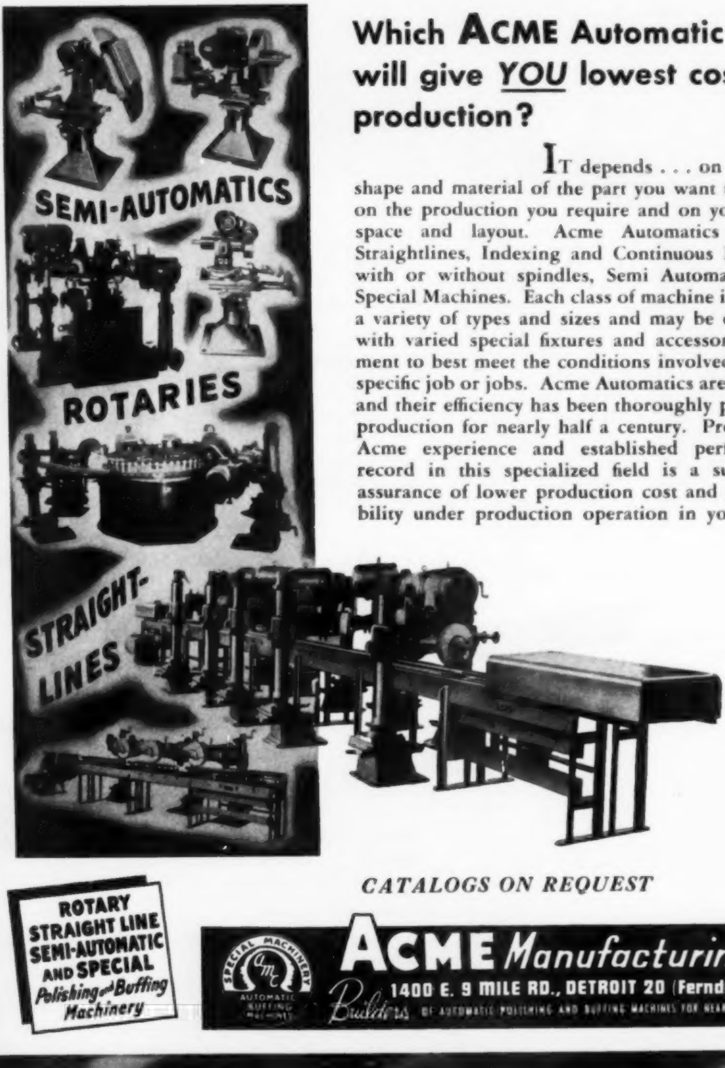
"ROCKWELL" HARDNESS TESTERS



Flow Chart of McKee Glass Company raw material handling system in which Ni-Hard pipe is used to resist abrasive wear.

ACME *Automatic*

Polishing and Buffing Machines



Which ACME Automatic will give <u>YOU</u> lowest cost production?

IT depends . . . on the size, shape and material of the part you want to finish; on the production you require and on your plant space and layout. Acme Automatics include Straightlines, Indexing and Continuous Rotaries, with or without spindles, Semi Automatics and Special Machines. Each class of machine is built in a variety of types and sizes and may be equipped with varied special fixtures and accessory equipment to best meet the conditions involved in your specific job or jobs. Acme Automatics are versatile and their efficiency has been thoroughly proved in production for nearly half a century. Progressive Acme experience and established performance record in this specialized field is a substantial assurance of lower production cost and dependability under production operation in your plant.

CATALOGS ON REQUEST

ROTARY
STRAIGHT LINE
SEMI-AUTOMATIC
AND SPECIAL
Polishing and Buffing Machinery

ACME *Manufacturing Co.*

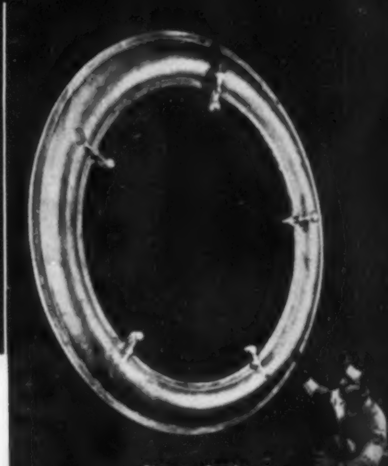
1400 E. 9 MILE RD., DETROIT 20 (Ferndale) MICH.

Builders OF AUTOMATIC POLISHING AND BUFFING MACHINES FOR NEARLY HALF A CENTURY


FIGHT WEAR
...in both Product and Plant
New RSC Super Saw attachment for heavy-duty ¼" electric drills provides an all-purpose, portable power-saw for cutting wood siding, "Inselbrick," "Ebonite," "Transite," fibre, Formica, galvanized sheet and other metals, cable, pipe, wire, nails, etc., — any shape: curves, angles, circles. No starting hole is needed.
R. C. S. TOOL SALES CORP.
Joliet, Illinois
APPLICATION:
The connecting rod actuated by an eccentric is the heart of the Super Saw. Ampco Metal was selected as the ideal material for this part, because of its high strength and ability to resist wear.
RESULT:
The Super Saw can be used for continuous service, day in and day out.
IT'S PRODUCTION-WISE TO AMPCO-IZE!


Gear blank — Centrifugally-cast


Centrifugal Casting


Ring — Sand-cast.

---with

AMPCO*

METAL

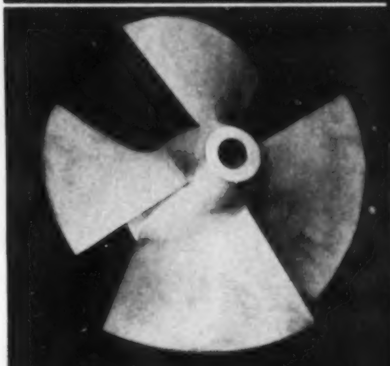
You can save plenty of money and eliminate lots of trouble with high-strength Ampco Metal.

You see, Ampco Metal resists wear — such types of wear as erosion, abrasion and cavitation-erosion. It also resists corrosion. That's why so many designers are putting Ampco Metal to work in their products. They want longer part life, better performance.

Moreover, thanks to its various hardness ranges, Ampco Metal is ideal for a wide variety of product services and plant-maintenance jobs. It resists both wear and squashing out — stands up under the heaviest kind of service.

And Ampco Metal is easy to use. It's available in bars, sheet, plate, tubing, sand and centrifugal castings, forgings, wire and welding electrodes — practically any form you want. When extra performance life is needed both in manufactured products and in production, specify Ampco Metal. Consult your nearest Ampco field engineer or send coupon for further information.

*Reg. U. S. Pat. Off., Ampco Metal, Inc.


Vanes — Sand-cast.


Bushings — Centrifugally-cast Ampco Grade 18 standard bars.

Tear out this coupon and mail today!

Ampco Metal, Inc.
Milwaukee 46, Wisconsin
West Coast Plant
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AMPCO

AMPCO METAL, INC., Dept. MP-10, Milwaukee 46, Wisconsin

Send me your free Ampco Metal literature giving descriptions and general applications of Ampco Metal.

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Brass Castings for Corrosion Resisting Qualities!
FIVE THOUSAND YEARS of human experience is adequate testimony that Copper Alloys effectively resist the destructive forces of corrosion. Throughout the ages and especially today, Brass and Bronze Alloys coupled with skillful craftsmanship, consistently prove themselves best for plumbing installations. That is why . . .
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ROLOCK

FABRICATED ALLOYS

HEAT AND CORROSION RESISTANT

SAVE SECONDS TO *PREVENT* SECONDS

The design and construction of this Rolock engineered-to-the-job furnace basket is a practical example of heat and quench efficiency.

Vital seconds are saved thru operation of the two-piece center drop-bottom grid which dumps a dense load more uniformly than the usual one-piece grid with single hinge. It is foolproof... instant... rugged. The work hits the quench at practically its maximum temperature for uniform, high quality pit type furnace heat treating. Fabricated-welded construction and the use of a high nickel alloy insure long service life, thus conserving scarce nickel.

Basket weight is 157 lbs.; load 1200 lbs.; a favorable high ratio of almost 8 to 1.

Rolock engineers welcome opportunities to solve tough material handling problems. Their assistance is yours on request.

• See our exhibit at the Metal Show, October 15-19 Detroit, Mich., Building D, Booth D140.

Offices in: PHILADELPHIA • CLEVELAND • DETROIT • HOUSTON • INDIANAPOLIS • CHICAGO • ST. LOUIS • LOS ANGELES • MINNEAPOLIS

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JOB-ENGINEERED for better work Easier Operation, Lower Cost

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Superior gives your products these *Superior* sales benefits

In your product planning for tomorrow, include SUPERIOR Stainless—for the sales appeal and fabricating dependability that will make future profits assured!

Superior Stainless Strip Steel improves product appearance, adds long life and easy maintenance—while providing handling qualities that are consistently uniform, thanks to always-precise dimensions and exactness of desired composition and temper.

Let us send you technical data for your reference files.

Superior Steel
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NEW SUPER QUENCH OIL . .

. . . GIVES YOU TRIPLE ACTION!

1 FASTER, DEEPER HARDENING

Mineral intensifiers give Park Triple A Oil faster quenching speed through the critical range, resulting in faster and deeper hardening.

2 LESS DISTORTION

Fast, uniform hardening in the critical range, plus a low cooling rate through the temperature zone of martensite formation, means less distortion from Park Triple A Oil.

Unretouched photographs of precision parts quenched from a carbo-nitriding furnace in Park Triple A Quench Oil. From left to right are parts quenched the first day, 30 days later, 60 days later, and 90 days later. Bright and clean after over 3 months use with no indication of reduction of surface cleanliness.

3 BRIGHT QUENCHING

Special anti-oxidants used in Park Triple A Oil give it greater stability for longer life and bright quenching properties. This is important when work is quenched from carbo-nitriding furnaces.

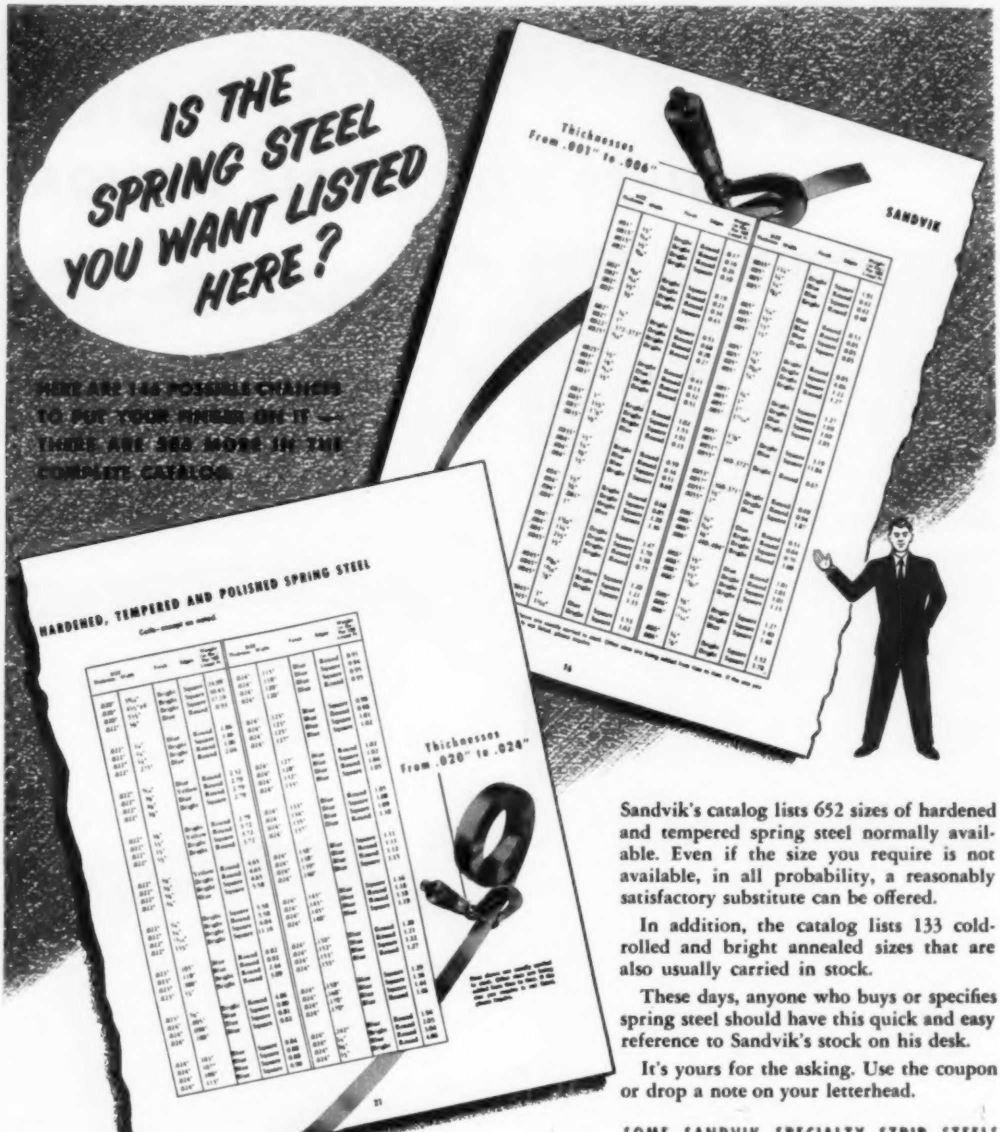
For Hot Oil Quenching up to 450° F use Park Thermo Quench Oil. Send for Bulletin No. F-7.

For These Critical Times . . .

Now more than ever you will need Park Triple A Quench Oil . . . with steels of critical hardenability due to lean alloy content and parts manufactured under government contracts, you can't afford costly rejects due to rigid inspection. Get the most from your quench oil — get Park Triple A Quench Oil today and save on critical material and expensive rejects. Send for Bulletin No. F-8 today, for complete information.

Park
CHEMICAL COMPANY

SEE US AT THE METAL SHOW—BOOTH F-456



Sandvik's catalog lists 652 sizes of hardened and tempered spring steel normally available. Even if the size you require is not available, in all probability, a reasonably satisfactory substitute can be offered.

In addition, the catalog lists 133 cold-rolled and bright annealed sizes that are also usually carried in stock.

These days, anyone who buys or specifies spring steel should have this quick and easy reference to Sandvik's stock on his desk.

It's yours for the asking. Use the coupon or drop a note on your letterhead.

55-70

SANDVIK STEEL, INC. Dept. M
111 Eighth Ave., New York 11, N. Y.

Please send me my free copy of your Spring Steel Catalog.

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SOME SANDVIK SPECIALTY STRIP STEELS

Band Saw Steels; Wood Band, Butcher Band and Metal Band • Steel for Textile Machine Parts • Camera Shutter Steel • Clock and Watch Spring Steels • Compressor Valve Steel • Doctor Blade Steel • Feeler Gauge Steel • Razor Blade Steel • Reed Steels • Shock Absorber Steel • Sinker Steel • Spring Steels • Trowel Steel • Vibrator Reed Steel, etc.

Sandvik Quality Steels

SANDVIK STEEL, INC.
111 EIGHTH AVE., N.Y. 11, WA 9-7180
230 N. Michigan Ave., Chicago 1, FR 2-5638
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SANDVIK CANADIAN LTD.
426 McGill St., Mont., Can.

The newly designed Projectomatic balance makes possible automatic weighings from 1/10 mg to 100 mg, the results of which may be read on the magnified image of the scale which is projected onto a conveniently located screen.

In addition to the unique projection device, this balance features a new "floating" neoprene-cushioned black glass base plate to which no mechanism is mounted. With this arrangement breakage hazards are minimized, and a sturdy more rigid construction is achieved.

The model AB-1 is a double pan balance. Accordingly on a balance of this type it is possible to tare containers. Since it is recognized that in many weighing operations taring is an absolute necessity, a balance of the AB-1 type is desirable for most installations. In addition, this type of balance, although adapted for repetitive weighing, is ideal for routine laboratory work.

H-1843—Christian Becker Projectomatic Analytical Balance . . . . Each **$795.00**

Specifications

Capacity—200 grams.

Beam—18.1 cm, of a special alloyed aluminum of great strength and uniform density. The beam is graduated left to right, 0 to 1 gram in 0.1 gram graduations (no weights below 1 gram required).

Projection System—the new Projectomatic makes possible automatic weighings from 1/10 mg to 100 mg. A vernier is provided for direct and positive reading to 0.1 mg. The zero of the screen is readily adjustable from outside the case.

Knife Edges—Agate. All knife edges are rigidly set in the beam.

Bearings—Agate Planes.

Releasing Mechanism—Beam Arrest. The special construction of the beam arrest insures the positive alignment of the agate edges with their respective bearings.

Damper—Magnetic damping arrests the oscillation of the beam almost immediately.

Rider Carrier—The enclosed vertical lift insures accurate alignment, in all positions, of lifting hook with the beam.

Pans—Stainless Steel, $2\frac{7}{8}$ in. diameter.

Bows—Brass, coated with a hard chemically resistant lacquer. Straight sides to accommodate large drying tubes, etc., $4\frac{1}{8}$ in. x $8\frac{1}{2}$ in. high.

Pan Arrest—The new independent pan arrest for pans with a positive stop.

Vibration Dampers—Special built-in dampers at each balance support dampen objectionable outside vibrations.

Sash Balance—The newly developed stainless sash balance for raising the front door eliminates the troublesome sash weights. The door opens wider, and more smoothly.

Case—$18\frac{1}{4}$ in. x 9 in. x 20 in. high. Aluminum with glass top and front panel and a removable back panel. The newly designed sliding front door, which actually comprises a portion of the side of the case, eliminates the objectionable conventional front corner posts. The case exterior is finished in an attractive chemically resistant finish. The interior is white to brighten working area. Case provided with a drawer.

HARSHAW SCIENTIFIC
DIVISION OF THE HARSHAW CHEMICAL CO.
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ROUND AND SHAPED TUBING
.010'' to ⅝'' O.D. Max. Certain Analyses .035'' max. wall to 1⅜'' O.D. Available in:
Carbon Steels:
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Nickel Alloys:
Nickel, "D Nickel"*, "L Nickel"*, "Monel"*, "K Monel"*, "Inconel"*, 30% Cupro Nickel, 18% Nickel Silver.
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THE HOLE STORY
by Superior
Chapter 4
Putting the Squeeze on Tubing —to End Bends!
Whether you use fine small tubing as a medium for transporting fluids or gases—or fabricate it into component parts—you want it straight as an arrow to start. That's where the machine pictured above comes in.
Commercial straightness is easily attained with Superior's numerous types of specialized straightening equipment.
In the normal course of tube drawing operations, unequal stresses are set up and the resultant tube has bends and bows which must be removed.
All these stresses are equalized in one operation. The tube is straightened and the end result is a better product for you.
To produce the world's best tubing we inspect and check many times, mechanically and metallurgically. We use microscopes to check grain structure, and keen-eyed inspectors to detect surface scratches, splits and pits. Pressure tests find any possible flaws in the walls. A continuing program keeps every Superior production worker aware of his part in the quality picture.
What does this mean to you?
It means you get fine small tubing that will do the toughest jobs better. Right now (because of Defense Orders and metal shortages) we may not be able to fill all of your tubing requirements, but it will pay you to check with your Superior distributor—he may have enough tubing in stock to help you. Always specify Superior Tubing and you'll always be right.
Superior Tube Company, 2008 Germantown Ave., Norristown, Pa.
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Superior
THE BIG NAME IN SMALL TUBING
All analyses .010'' to ⅝'' O.D.
Certain analyses (.035'' max. wall)
Up to 1⅜'' O.D.

Cleveland Photo — Aerial Surveys, Inc.

the wheelco recorder

In Cleveland factories, whether it's tin cans or the food in the cans—delicate hair springs or giant gears—fine ceramic ware or sturdy milk bottles—colorful auto paint or engine oil—the Wheelco Recorder accurately writes a diverse production history. For invaluable assistance in your own plant, follow the lead of progressive production men—for measurement, indication, control and recording of electrically measurable variables, specify the economical Wheelco Capacilog, deflection type, strip chart recorder.

Yes, for accuracy to ¼ of 1% of total scale, specify the Wheelco Capacilog. Capacilogs are built for use with thermocouples and resistance thermometer measuring elements; as single or multipoint recorders, and with six different control combinations including pneumatic and electric proportioning types. Remember, in Cleveland and throughout the nation where production records are set, they're made and kept on Wheelco recorders.

Assembly line production and simplicity of construction make it possible to deliver most models within 20 days.

Visit the Wheelco Booth #D-219, National Metal Exposition & Congress, Detroit, Michigan, October 15-19

Wheelco Instruments Company, 835 W. Harrison Street, Chicago 7, Illinois

wheelco *electronic controls*

HOW TO GET THE MOST OUT OF THE

"lean alloys do the job when we use U·S·S Improved Heat Treatment*"

says **C. E. WILDERMAN**,

Vice President, Tool Division, Utica Drop Forge & Tool Corp., Utica, N. Y.

*available without charge

". . . lean alloys forge easier than high alloys, so we get longer die life."

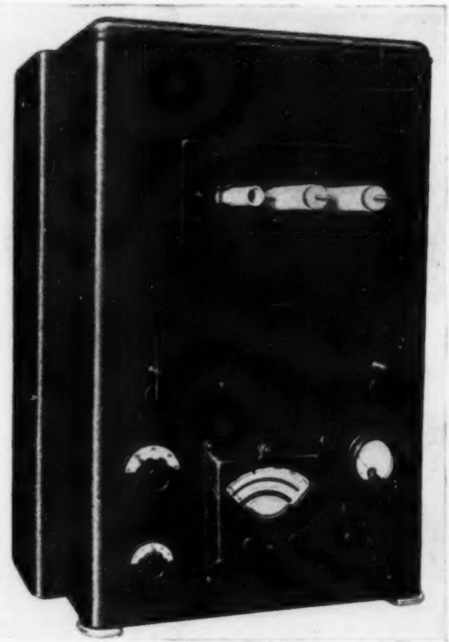
". . . drilling and machining operations are simplified."

". . . working faces are easily induction hardened." Notice dark sections on jaw faces.

". . . torque tests average 25,000 in. lbs. against 7,650 in. lbs. required by Federal Specifications."


BOLTMAKER
COLD NUT FORMER
Our Job: HELPING YOU
NAILMAKER
PROGRESSIVE HEADER
COLD HEADER
TUBULAR RIVET HEADER
ROLLER HEADER
BALL HEADER

4 Ways GLOBAR Heating Elements Boost Furnace Performance



• HITEMP

1 ACCURATE. GLOBAR silicon carbide elements when properly applied and operated assure uniform temperatures . . . maintain consistent product quality.

2 CLEAN. GLOBAR heating elements radiate clean efficient heat.

3 DEPENDABLE. GLOBAR elements can be depended upon for long economical life. Help you maintain production schedules. Easy to install and service.

4 VERSATILE. GLOBAR elements are specified "musts" by many leading users of electric furnaces. Used successfully for most types of heat treating applications.

DIETERT USES GLOBAR ELEMENTS. Accuracy is essential in all phases of design, construction and operation of high temperature laboratory combustion furnaces. GLOBAR elements meet all requirements . . . add to efficient performance of such furnaces.

• VARITEMP

Furnaces illustrated are made by Harry W. Dietert Company, Detroit, Michigan

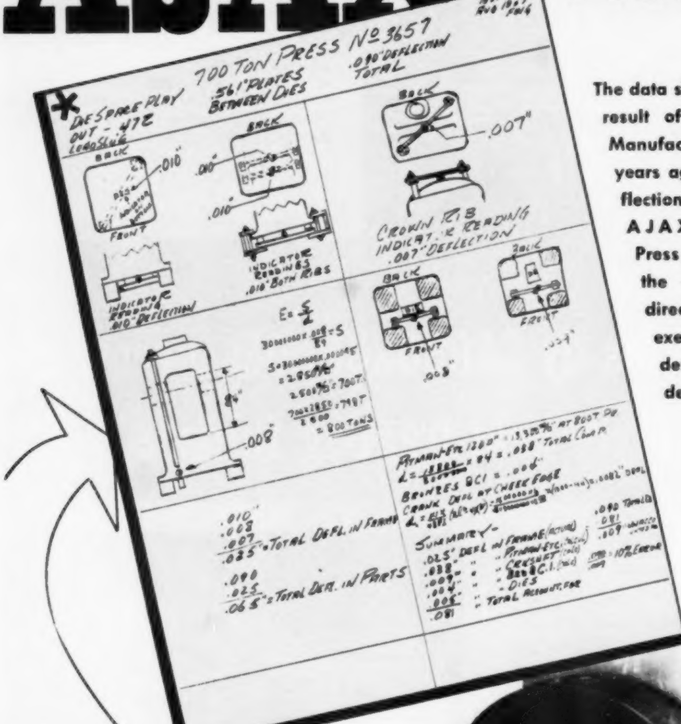
GLOBAR heating elements provide many other important advantages. For complete information, write Dept. **MP 101,** GLOBAR Division, The Carborundum Company, Niagara Falls, New York.

GLOBAR Heating Elements BY CARBORUNDUM

TRADE MARK

"Carborundum" and "Globar" are registered trademarks which indicate manufacture by The Carborundum Company

AJAX ENGINEERING PIONEERING



The data sheet on the left shows the original result of a test performed at the Ajax Manufacturing Co. plant in 1937, fourteen years ago. Here are the readings of deflections at different locations on an AJAX seven-hundred ton Forging Press Frame. This method of reading the deflections of a Press Frame directly to determine the tonnage exerted, enabled our engineers to design frames for a minimum deflection at critical locations.

Illustrated Below

2000 ton AJAX Solid Frame Forging Press Equipped with Disc Brake, Built in 1937

This old sketch of a press frame shows the use of a dial indicator and guage rod to read the elongation of the frame under load, which is a direct function of the tonnage exerted.

Fourteen Years Ago . . .

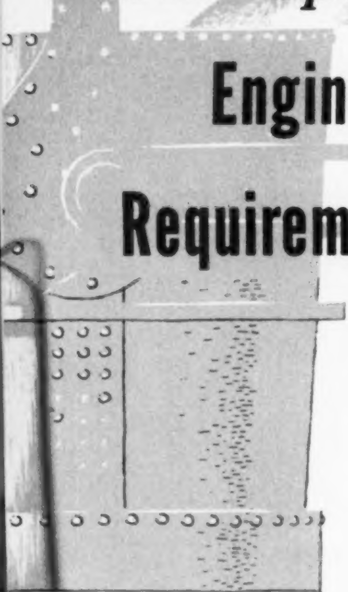
A two-thousand ton Ajax Forging Press equipped with a disc brake, believed to be the first of its type, used on a Forging Press

Built by **AJAX**

THE Ajax MANUFACTURING COMPANY
EUCLID BRANCH P. O. CLEVELAND 17, OHIO
110 S. DEARBORN ST. CHICAGO 3, ILLINOIS
DEWART BUILDING NEW LONDON, CONN.


NORTON
REFRACTORIES
NORTON
Special REFRACTORIES
MAKING BETTER PRODUCTS TO MAKE OTHER PRODUCTS BETTER
. . . For the Metal Processing Industry

Norton *Special* Refractories Are Engineered To Fit Your <u>Exact</u> Requirements



You are always looking for new ways to improve your products, increase your production and lower your costs. That's why you'll find a valuable partner in Norton Refractory Research.

For 40 years, Norton Research has pioneered in the development of special refractories for high temperature applications that are complicated by chemical, electrical, and physical variables.

Working with many electric furnace products, Norton Research has created a wide variety of special refractories having properties of great value in metal processing. These are CRYSTOLON* (silicon carbide), ALUNDUM* (fused alumina), MAGNORITE* (fused magnesia), and FUSED STABILIZED ZIRCONIA. A few of these products are discussed here. For more complete information, call your nearby Norton refractories engineer, or write Norton Company, Refractories Division, Worcester 6, Mass.

IN HIGH FREQUENCY INDUCTION FURNACES, you can melt more steel as well as heat- and corrosion-resistant alloys per lining using Norton MAGNORITE cement. Designed specifically to be rammed dry, it begins to mature at 2100° F. and withstands temperatures up to 3250° F. Only the inner face matures during the wash heat, thereby eliminating shrinkage cracks which permit metal penetration that can short out your furnace. MAGNORITE crucibles are available for smaller furnaces.

For melting platinum and its alloys Norton FUSED STABILIZED ZIRCONIA crucibles are ideal. Since they are not wetted by the metal, you recover 100% of the melt without destroying the crucible and can also use the same furnace for different alloys without contamination.

IN INDIRECT ARC FURNACES you'll get the results you want with Norton ALUNDUM and MAGNORITE crocks and covers or cements. As these products are made to meet individual requirements, send us your specifications for the recommendation that will assure you the most satisfactory results.

IN LOW FREQUENCY INDUCTION FURNACES, you have a choice of ALUNDUM and MAGNORITE cements, depending upon the metals you are melting. Long lining life is obtained in melting the refractory alloys, including cupronickel, nickel silver, high copper alloy, as well as Al, Te, and Si bronzes, because of the great refractoriness of these cements. Greater economy is also realized because of their high rammed density which resists metal penetration and erosion.

IN PIT, CRUCIBLE, AND REVERBERATORY FURNACES for nonferrous melting, linings of Norton CRYSTOLON cements and fired shapes let you melt more metal with fewer interruptions for maintenance. Fired shapes of CRYSTOLON refractory are also available for special applications. For example, CRYSTOLON protection tubes are being successfully used for more accurate control of metal temperatures.

IN BACK-SLAGGING CUPOLAS, slag hole blocks made of Norton CRYSTOLON refractory enable you to complete your campaigns without stopping for replacement. Made of densely bonded, chemically inert silicon carbide grain, they resist corrosion, erosion, and penetration of slag many times longer than fireclay blocks. No softening or spalling at temperatures up to 3050° F. It will pay you to compare Norton CRYSTOLON slag hole blocks with whatever you are now using.

IN HEAT-TREATING AND SINTERING FURNACES, a wide variety of Norton refractory products are contributing to higher operating temperatures and lower operating costs. ALUNDUM and CRYSTOLON hearthplates, pier brick, burner blocks, muffles, muffle plates, skid rails, burner tunnel cements, and embedding cements offer such desirable properties as high refractoriness and excellent resistance to spalling, corrosion, and erosion.

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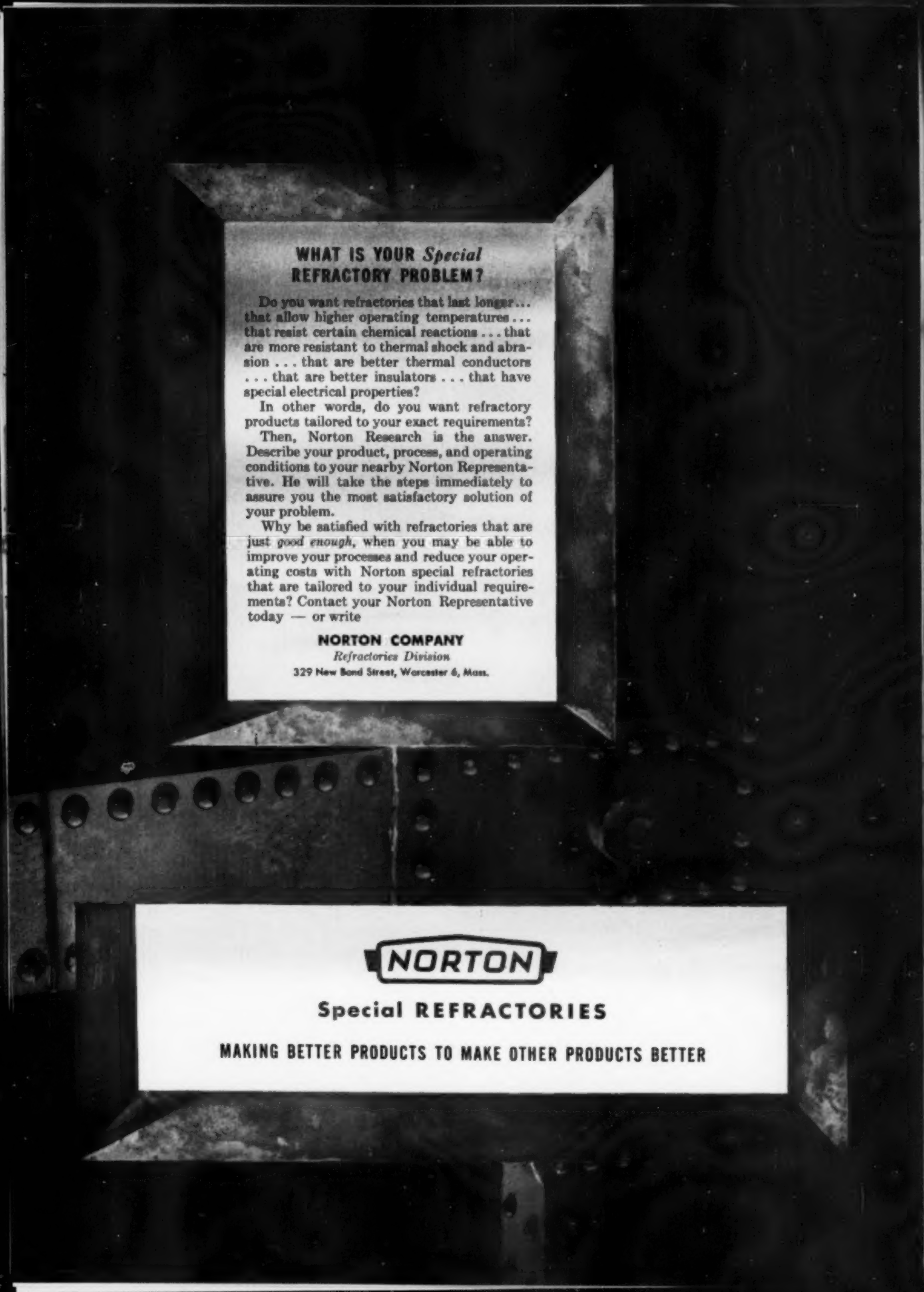
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Metal Progress

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Ernest E. Thum, *Editor*

John Parina, Jr., *Associate Editor*

Cover by Vincent Rapini

World Metallurgical Congress

Technical Articles

Correspondence

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Abstracts of Important Articles

The World Metallurgical Congress

A Statement by the President, ⊜

FRIENDSHIP, cooperation, mutual assistance among metal scientists and metallurgical engineers of the free world to promote a peaceful and advancing civilization is well symbolized in the handsome bronze medal prepared for conferees to the first World Metallurgical Congress. It is fitting that the American Society for Metals, the world's premier association of men interested in manufacture and utilization of superior metals and alloys, should be the sponsor of this Congress, and that all the facilities and advantages of the A.S.M.'s Annual Convention and National Metal Exposition should be thrown open to our visitors from overseas.

We confess that we Americans expect to get as much from our visitors as we give! Everyone who has participated even in a small way in those familiar (to us) activities known as engineering societies knows that when he brings ideas into a congenial group they generate new ideas; all become richer for the interchange. It is therefore a rare privilege which members of the ⊜ will embrace to come to Detroit—by Oct. 13 if possible—and extend personal welcome to our visitors, enter into the professional discussions at the group meetings and technical sessions, meet them socially, show them how free men in a free country conduct themselves.

I recommend that everyone examine the consolidated general program in the following pages and get an idea of the variegated activities, then go on to the list of American and foreign papers to be presented in the regular technical programs, and finally read the articles in this issue of *Metal Progress,* exclusively given over to a small sampling of the contributions from foreign lands. An inescapable conclusion is that here is intellectual fare of supreme quality. Fifteen of the papers by foreign conferees find place in the ⊜ technical program; the balance will be considered in the group meetings; the entire 47 will be published in a separate volume containing the proceedings of the World Metallurgical Congress.

It would be well to recount briefly the inception of this Congress. It was conceived by Wm. H. Eisenman and first presented by him and my predecessor as president of the ⊜, Arthur E. Focke, to Paul G. Hoffman, then head of the Economic Cooperation Administration, in December 1949. It met instant acceptance, but time proved too short to make the multitudinous arrangements before our convention last year in Chicago. Consequently, the Congress was deferred until 1951 and really got off to a flying start during the European tour early this year of Zay Jeffries, past president ⊜ and director general of the World Metallurgical Congress.

While Secretary Eisenman originated the broad project and gave a large share of his time to the planning in all its details, Ernest E. Thum, editor of *Metal Progress,* acted in his behalf during those periods when Mr. Eisenman was necessarily absent, organized the eight four-week tours in various branches of our metal industry, and the general activities for conferees during convention week. Many contacts with the American governmental agencies and foreign embassies were made in Washington by John W. Barnet, ⊜, assistant director general of the Congress. Kingsley W. Given, formerly of General Electric's staff, served as executive assistant and superintended the activities of four other temporary employees in working out the details of reception, travel and plant visitations. Marjorie Rud Hyslop, editor of *Metals Review,* acted as registrar and supervised the voluminous correspondence. Ray T. Bayless, assistant secretary ⊜, attended to details of the Detroit technical conferences and all matters concerning publication. A. A. Hess, assistant treasurer, worked out the special accounting methods required by the E.C.A.

It is not too much to say that every member of the ⊜ general office staff took a share in the extraordinarily diverse arrangements for the World Metallurgical Congress, and I have been gratified by the unselfish manner in which they have contributed the necessary extra effort. When working together, as free men and women know how to do, success is assured.

WALTER E. JOMINY
President
American Society for Metals

Glenn M. Shaw, Designer
Walter A. Sinz, Sculptor
Medallic Art Co., Manufacturer

• CONSOLIDATED PROGRAM •

33d National Metal Congress

and First World Metallurgical Congress

AMERICAN SOCIETY FOR METALS

INSTITUTE OF METALS DIVISION,

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS (A.I.M.E.)

AMERICAN WELDING SOCIETY (A.W.S.)

SOCIETY FOR NON-DESTRUCTIVE TESTING (S.N.T.)

SPECIAL LIBRARIES ASSOCIATION (S.L.A.)

Saturday, October 13, 1951

10:00 A.M. and 2:00 P.M. Seminar: Interfaces; Ballroom, Statler Hotel

Sunday, October 14, 1951

10:00 A.M. Seminar: Interfaces; Ballroom, Statler Hotel

2:00 P.M. Seminar: Interfaces; Wayne Room, Statler Hotel

2:00 P.M. and W.M.C. Conferee Meeting; Hall of Friendship, Hotel Tuller

4:00 P.M. and W.M.C. Civic Reception; Ballroom, Statler Hotel

7:00 P.M. A.I.M.E. Program Committee; Tropical Room, Detroit-Leland Hotel

7:00 P.M. A.I.M.E. Publications Committee; New York Room, Detroit-Leland Hotel

8:00 P.M. First Meeting of W.M.C.; Ballroom, Statler Hotel

Monday, October 15, 1951

9:00 A.M. A.I.M.E. Grain Growth and Recrystallization; Jade Room, Detroit-Leland Hotel

9:00 A.M. A.I.M.E. Alloys Systems; Colonial Room, Detroit-Leland Hotel

9:30 A.M. W.M.C. Tour Groups 2, 6 and 8 Meetings; Hotel Tuller

9:30 A.M. Constitution Diagrams; Ballroom, Statler Hotel

9:30 A.M. W.M.C. Melting and Refining; Wayne Room, Statler Hotel

9:30 A.M. A.W.S. Structural Welding; Crystal Ballroom, Book-Cadillac Hotel

9:30 A.M. A.W.S. Resistance Welding; Italian Garden, Book-Cadillac Hotel

9:30 A.M. S.N.T. Technical Session; Flamingo Room, Hotel Detroiter

12:00 M. Opening of National Metal Exposition and House of Friendship; Michigan State Fair Grounds

2:00 P.M. W.M.C. Tour Groups 3, 4 and 11 Meetings; Michigan State Fair Grounds

2:00 P.M. Diffusion, Building M, Fair Grounds

Monday's Program, Continued

2:00 P.M. A.I.M.E. Dislocations in Metals; Jade Room, Detroit-Leland Hotel

2:00 P.M. A.W.S. Resistance Welding; Italian Garden, Book-Cadillac Hotel

2:00 P.M. A.W.S. Weldability; Grand Ballroom, Book-Cadillac Hotel

2:00 P.M. A.W.S. Nonferrous; Crystal Ballroom, Book-Cadillac Hotel

2:00 P.M. S.N.T. Technical Session; Flamingo Room, Hotel Detroiter

4:00 P.M. W.M.C. High Tea; House of Friendship, Fair Grounds

6:00 P.M. A.W.S. President's Reception; Grand Ballroom, Book-Cadillac Hotel

7:00 P.M. A.I.M.E. Membership Committee; New York Room, Detroit-Leland Hotel

8:00 P.M. First Lecture: Residual Stress Measurements; Building M, Fair Grounds

8:00 P.M. A.I.M.E. Dislocations in Metals; Jade Room, Detroit-Leland Hotel

Tuesday, October 16, 1951

9:00 A.M. A.I.M.E. Transformations; Jade Room, Detroit-Leland Hotel

9:00 A.M. A.I.M.E. Alloy Systems; Colonial Room, Detroit-Leland Hotel

9:30 A.M. Tour Groups 1, 5 and 9 Meetings; Hotel Tuller

9:30 A.M. W.M.C. High-Temperature Alloys; Ballroom, Statler Hotel

9:30 A.M. W.M.C. Mechanical Metallurgy; Wayne Room, Statler Hotel

9:30 A.M. A.W.S. Ship Structure; Crystal Ballroom, Book-Cadillac Hotel

9:30 A.M. A.W.S. Arc Welding; Italian Garden, Book-Cadillac Hotel

9:30 A.M. S.N.T. Technical Session; Flamingo Room, Hotel Detroiter

Exposition and House of Friendship
Open 12:00 M. to 10:30 P.M.

Tuesday's Program, Continued

12:15 P.M. A.I.M.E. Executive Committee Luncheon; New York Room, Detroit-Leland Hotel

2:00 P.M. W.M.C. Tour Groups Meetings; Fair Grounds

2:00 P.M. ⊜ High-Temperature Alloys; Building M, Fair Grounds

2:00 P.M. A.I.M.E. Light Metals; Jade Room, Detroit-Leland Hotel

2:00 P.M. A.I.M.E. Creep; Colonial Room, Detroit-Leland Hotel

2:00 P.M. A.W.S. Ship Structure; Crystal Ballroom, Book-Cadillac Hotel

2:00 P.M. A.W.S. Hard Facing and Flame Hardening; Grand Ballroom, Book-Cadillac Hotel

2:00 P.M. A.W.S. Resistance Welding; Italian Garden, Book-Cadillac Hotel

2:00 P.M. S.N.T. Technical Session; Flamingo Room, Hotel Detroiter

4:00 P.M. W.M.C. High Tea; House of Friendship, Fair Grounds

4:30 P.M. ⊜ Heat Treatment; Building M, Fair Grounds

4:30 P.M. A.W.S. Educational Lecture; Italian Garden, Book-Cadillac Hotel

7:00 P.M. A.I.M.E. Annual Fall Dinner; Jade Room, Detroit-Leland Hotel

8:00 P.M. ⊜ Residual Stress Measurements; Building M, Fair Grounds

8:00 P.M. A.W.S. Adams Lecture; Crystal Ballroom, Book-Cadillac Hotel

Wednesday, October 17, 1951

9:00 A.M. ⊜ Annual Meeting; Ballroom, Statler Hotel

9:30 A.M. ⊜ Campbell Memorial Lecture; Ballroom, Statler Hotel

9:30 A.M. A.W.S. Production Welding; Crystal Ballroom, Book-Cadillac Hotel

9:30 A.M. A.W.S. Pressure Vessels; Grand Ballroom, Book-Cadillac Hotel

9:30 A.M. A.W.S. Gas Cutting; Italian Garden, Book-Cadillac Hotel

9:30 A.M. S.N.T. Ordnance Material Testing; Flamingo Room, Hotel Detroiter

12:00 M. American College Alumni Luncheon; Statler Hotel and Hotel Tuller

Exposition and ⊜ House of Friendship
Open 12:00 M. to 10:30 P.M.

12:15 P.M. A.I.M.E. Powder Metallurgy Committee Luncheon; New York Room, Detroit-Leland Hotel

2:00 P.M. W.M.C. Adjourned Meetings of Study Tour Groups 1 through 12; Fair Grounds

2:00 P.M. ⊜ Embrittlement; Building M, Fair Grounds

2:00 P.M. A.W.S. Weldability; Grand Ballroom, Book-Cadillac Hotel

2:00 P.M. A.W.S. Welding and Brazing; Crystal Ballroom, Book-Cadillac Hotel

2:00 P.M. A.W.S. Stainless Steels; Italian Garden, Book-Cadillac Hotel

2:00 P.M. A.I.M.E. High-Temperature Oxidation; Colonial Room, Detroit-Leland Hotel

2:00 P.M. S.N.T. Jet Engine Part Inspection; Flamingo Room, Hotel Detroiter

2:30 P.M. A.I.M.E. Powder Metallurgy; Jade Room, Detroit-Leland Hotel

Wednesday's Program, Continued

4:00 P.M. W.M.C. High Tea; House of Friendship, Fair Grounds

4:30 P.M. ⊜ Heat Treatment; Building M, Fair Grounds

4:30 P.M. A.W.S. Educational Lecture, Italian Garden, Book-Cadillac Hotel

7:30 P.M. A.W.S. University Research Conference; Founders Room, Book-Cadillac Hotel

8:00 P.M. ⊜ Heat Treatment; Building M, Fair Grounds

Thursday, October 18, 1951

9:30 A.M. W.M.C. Adjourned Meetings of Study Tour Groups 1 through 12; Michigan State Fair Grounds

9:30 A.M. ⊜ W.M.C. High-Temperature Phases; Building M, Fair Grounds

9:30 A.M. A.W.S. Educational; Crystal Ballroom, Book-Cadillac Hotel

9:30 A.M. A.W.S. Weldability; Italian Garden, Book-Cadillac Hotel

9:30 A.M. A.W.S. Inert Arc Welding; Grand Ballroom, Book-Cadillac Hotel

9:30 A.M. S.N.T. Technical Session; Flamingo Room, Hotel Detroiter

10:00 A.M. S.L.A. Technical Session; English Room, Statler Hotel

Exposition and ⊜ House of Friendship
Open 10:00 A.M. to 6:00 P.M.

2:00 P.M. W.M.C. Adjourned Meetings of Study Tour Groups 1 through 12; Building M, Fair Grounds

2:00 P.M. ⊜ Heat Treatment; Building M, Fair Grounds

2:00 P.M. A.W.S. Filler Metal Specifications for Inert Gas and Submerged Arc Welding; Crystal Ballroom, Book-Cadillac Hotel

2:00 P.M. A.W.S. Business Meeting; Italian Garden, Book-Cadillac Hotel

2:00 P.M. S.N.T. Honor Lecture and Annual Business Meeting; Flamingo Room, Hotel Detroiter

2:30 P.M. S.L.A. Technical Session; English Room, Statler Hotel

4:00 P.M. W.M.C. High Tea; House of Friendship, Fair Grounds

7:30 P.M. A.W.S. Annual Dinner and Presentation of Awards; Grand Ballroom, Book-Cadillac Hotel

Friday, October 19, 1951

9:30 A.M. W.M.C. General Meeting of Conferees; Building M, Fair Grounds

9:30 A.M. ⊜ Physical Metallurgy; Building M, Fair Grounds

9:30 A.M. A.W.S. Inert Arc Welding; Crystal Ballroom, Book-Cadillac Hotel

9:30 A.M. A.W.S. Metallizing; Italian Garden, Book-Cadillac Hotel

9:30 A.M. S.L.A. Technical Session; English Room, Statler Hotel

Exposition and ⊜ House of Friendship
Open 10:00 A.M. to 6:00 P.M.

2:00 P.M. W.M.C. General Meeting of Conferees; Building M, Fair Grounds

2:00 P.M. S.L.A. Technical Session; English Room, Statler Hotel

7:00 P.M. W.M.C. Farewell Dinner for Conferees; Ballroom, Statler Hotel

Details of Program

Saturday, Oct. 13, and Sunday, Oct. 14

Seminar on Metal Interfaces
9:30 A. M. and 2:00 P. M.
BALLROOM, STATLER HOTEL
WAYNE ROOM, STATLER HOTEL
A symposium of 13 papers with discussions

Sunday Evening, Oct. 14

8:00 P. M.—World Metal Resources
Opening Session of World Metallurgical Congress
BALLROOM, STATLER HOTEL

Raw Materials for the Metal Industry, by James Boyd, U. S. Department of the Interior.

Defense Metal Conservation and Substitution, by K. P. Harten, German Iron and Steel Institute.

Metals for Defense in the E.C.A. Countries. Speaker to be announced.

Metals for Defense in the Non-E.C.A. Countries of the Free World, by Clyde Williams, Battelle Memorial Institute.

Monday Morning, Oct. 15

Session on Constitution Diagrams
BALLROOM, STATLER HOTEL

9:30 A. M.—**Constitution and Properties of Cobalt-Iron-Vanadium Alloys,** by D. L. Martin and A. H. Geisler, General Electric Co., Research Laboratories.

10:00 A. M.—**Phase Relationships in the Iron-Chromium-Vanadium System,** by Howard Martens and Pol Duwez, California Institute of Technology.

10:30 A. M.—**A Partial Titanium-Chromium Phase Diagram and the Crystal Structure of $TiCr_2$,** by Pol Duwez and Jack L. Taylor, California Institute of Technology.

11:00 A. M.—**The Titanium-Silicon System,** by M. Hansen, H. D. Kessler and D. J. McPherson, Armour Research Foundation.

11:30 A. M.—**The Indium-Antimony System,** by T. S. Liu and E. A. Peretti, University of Notre Dame.

Session on Melting and Refining
WAYNE ROOM, STATLER HOTEL

*9:30 A. M.—**A Proposed Steelmaking Process,** by A. Reggiore, Societa Italiana Ernesto Breda, Italy.

*10:00 A. M.—**A New Process for Direct Reduction of Iron Pyrites,** by A. Scortecci and M. Scortecci, Finsider Metallurgical Institute, Italy.

*10:30 A. M.—**A Rapid Analytical Method for Hydrogen in Steel,** by Y. Ishihara and S. Sawa, Japan Special Steel Co., Japan.

*11:00 A. M.—**Basic Bessemer Steel With Low Nitrogen and Phosphorus,** by P. Coheur, Centre National de Recherches Metallurgiques, Belgium.

*11:30 A. M.—**Phosphorus Deoxidation of Molten Copper,** by W. A. Baker, British Non-Ferrous Metals Research Association, England.

Monday Afternoon and Evening, Oct. 15

Session on Diffusion
BUILDING M, FAIR GROUNDS

2:00 P. M.—**Interstitial Diffusion,** by A. G. Guy, University of North Carolina.

2:30 P. M.—**The Carbonitriding of Carbon and Alloy Steels,** by H. C. Fiedler, M. B. Bever and C. F. Floe, Massachusetts Institute of Technology.

3:00 P. M.—**Chromium Diffusivity in Alpha Cobalt-Chromium Solid Solutions,** by John W. Weeton, Lewis Flight Propulsion Laboratory, National Advisory Committee for Aeronautics.

3:30 P. M.—**Anisothermal Diffusion of Carbon in Austenite,** by J. E. Black, Captain, Ordnance Department, U. S. Army, Lehigh University.

8:00 P. M.—**Lectures on Residual Stress Measurements**
BUILDING M, FAIR GROUNDS

Origin, Nature and Effects of Residual Stresses, by R. G. Treuting, Bell Telephone Laboratories.

Measurements of Residual Stresses, by J. J. Lynch, Case Institute of Technology.

Tuesday Morning, Oct. 16

Session on High-Temperature Phases
BALLROOM, STATLER HOTEL

9:30 A. M.—**The Formation of Sigma Phase in 13 to 16% Chromium Steels,** by H. S. Link and P. V. Marshall, U. S. Steel Co., Research and Development Laboratory.

10:00 A. M.—**Electrolytic Etching — The Sigma Phase Steels,** by John J. Gilman, Crucible Steel Co. of America, Research Laboratory.

*10:30 A. M.—**Phase Changes Associated With Sigma Formation in 18-8-3-1 Chromium-Nickel-Molybdenum-Titanium Steel,** by K. W. Bowen and T. P. Hoar, University of Cambridge, England.

11:00 A. M.—**Composition Limits of Sigma Formation in Nickel-Chromium Steels at 1200° F. (650° C.),** by M. E. Nicholson, University of Chicago; C. H. Samans, Standard Oil Co. (Indiana); and F. J. Shortsleeve, Case Institute of Technology.

11:30 A. M.—**Ferrite Formation Associated With Carbide Precipitation in 18 Cr, 8 Ni Austenitic Stainless Steel,** by E. J. Dulis and G. V. Smith, U. S. Steel Co.

Session on Mechanical Metallurgy
WAYNE ROOM, STATLER HOTEL

9:30 A. M.—**The Determination of Flow Stress From a Tensile Specimen,** by E. R. Marshall and M. C. Shaw, Massachusetts Institute of Technology.

*10:00 A. M.—**Plastic Deformation of Zinc Bicrystals,** by T. Kawada, Government Mechanical Laboratory, Ministry of International Trade and Industry, Japan.

*10:30 A. M.—**The Mechanical Properties of Iron and Some Iron Alloys of High Purity,** by W. P. Rees, National Physical Laboratory, England.

*11:00 A. M.—**Crystal Orientation in Cold-Rolled Silicon Steel Sheet,** by I. Gokyu and H. Abe, Tokyo University, Japan.

11:30 A. M.—**Delayed Yield in Annealed Steels of Very Low Carbon and Nitrogen Content,** by D. S. Wood and D. S. Clark, California Institute of Technology.

Tuesday Afternoon and Evening, Oct. 16

Session on High-Temperature Alloys
BUILDING M, FAIR GROUNDS

2:00 P. M.—**Cast Heat Resistant Alloys of the 21% Chromium, 9% Nickel Type,** by Howard S. Avery, Charles R. Wilks and John A. Fellows, American Brake Shoe Co.

*World Metallurgical Congress papers submitted by foreign conferees.

Tuesday Afternoon and Evening (Cont.)

2:30 P. M.—**Influence of Extended Time on Creep and Rupture Strength of 16-26-6 Alloy,** by C. L. Clark and M. Fleischmann, Timken Roller Bearing Co., and J. W. Freeman, University of Michigan.

3:00 P. M.—**Isothermal Transformation, Hardening and Tempering of 12% Chromium Steel,** by R. L. Rickett, Research Laboratory, U. S. Steel Co.; C. S. Walton and J. C. Butler, U. S. Steel Co.

3:30 P. M.—**Cladding of Molybdenum for Service in Air at Elevated Temperature,** by W. L. Bruckart and R. I. Jaffee, Battelle Memorial Institute.

4:30 P. M.—**Lecture on Principles of Heat Treatment,** by M. A. Grossmann, Director of Research, U. S. Steel Co.

8:00 P. M.—Lectures on Residual Stresses

BUILDING M, FAIR GROUNDS

Residual Stress States Produced in Metals by Various Processes, by H. B. Wishart, U. S. Steel Co.

Relief and Redistribution of Residual Stresses in Metals, by D. G. Richards, United Aircraft Corp.

Wednesday Morning, Oct. 17

A.S.M. Annual Meeting and Lecture

BALLROOM, STATLER HOTEL

9:30 A. M.—**Annual Meeting of the Society**

10:00 A. M.—**Edward DeMille Campbell Memorial Lecture,** by C. H. Lorig, Supervising Metallurgist, Battelle Memorial Institute.

Wednesday Afternoon and Evening, Oct. 17

Session on Embrittlement

BUILDING M, FAIR GROUNDS

2:00 P. M.—**Effects of Decomposition of Retained Austenite During Tempering on Notch Toughness and Tensile Properties,** by E. F. Bailey and W. J. Harris, Jr., Naval Research Laboratory.

2:30 P. M.—**Comparison of the Effects of Alloying Elements on the Lower and Upper Transition Temperatures in Pearlitic Steel,** by J. A. Rinebolt and W. J. Harris, Jr., Naval Research Laboratory.

3:00 P. M.—**Effect of Retained Austenite Upon Mechanical Properties,** by L. S. Castleman, Atomic Power Div., Westinghouse Electric Corp.; B. L. Averbach and Morris Cohen, Mass. Institute of Technology.

3:30 P. M.—**Some X-Ray Diffraction and Electron-Microscope Observations on Temper-Brittle Steels,** by S. R. Maloof, Springfield Armory.

4:30 P. M.—**Lecture on Principles of Heat Treatment,** by M. A. Grossmann, Director of Research, U. S. Steel Co.

8:00 P. M.—**Lecture on Principles of Heat Treatment,** by M. A. Grossmann, Director of Research, U. S. Steel Co.

Thursday Morning and Afternoon, Oct. 18

Session on Mechanical Metallurgy

BALLROOM, STATLER HOTEL

9:30 A. M.—**Strain Aging Effects,** by J. D. Lubahn, Research Laboratory, General Electric Co.

10:00 A. M.—**Fatigue Strength of Large, Notched Steel Bars Surface Hardened by Gas Heating and by Induction Heating,** by S. L. Case, J. M. Berry and H. J. Grover, Battelle Memorial Institute.

*10:30 A. M.—**Deep Drawing Limits for Rectangular Boxes,** by T. Ishikawa, Nippon Aluminum Mfg. Co., Japan.

*11:00 A. M.—**Elimination of Yield Point Phenomena by Temper Rolling and Roller Leveling,** by N. H. Polakowski, University College, England.

11:30 A. M.—**Effect of High Heating Rate on Some Elevated-Temperature Tensile Properties of Metals,** by W. K. Smith, C. C. Woolsey and W. O. Wetmore, Metallurgy Branch, U. S. Naval Ordnance Test Station, China Lake, Calif.

Session on High-Temperature Phases

WAYNE ROOM, STATLER HOTEL

*9:30 A. M.—**An Interpretation of the Hysteresis Loops in A_3 and A_4 Transformations of Pure Iron,** by Kotaro Honda and Mizuho Sato, Scientific Research Institute, Japan.

*10:00 A. M.—**Magnetic Property Changes in Iron-Molybdenum Alloys During Aging,** by T. Mishima, R. Hasiziti and Y. Kamura, University of Tokyo, Japan.

*10:30 A. M.—**Age Hardening,** by Y. Mishima, Japan.

11:00 A. M.—**Carbide Reactions in High-Temperature Alloys,** by J. R. Lane, Naval Research Laboratory, and N. J. Grant, Massachusetts Institute of Technology.

*11:30 A. M.—**The Allotropy of Cobalt,** by A. G. Metcalfe, Deloro Smelting & Refining Co., Canada.

Session on Heat Treatment

BUILDING M, FAIR GROUNDS

2:00 P. M.—**Stress-Induced Transformation of Retained Austenite in Hardened Steel,** by B. L. Averbach, S. G. Lorris and Morris Cohen, Massachusetts Institute of Technology.

2:30 P. M.—**An Investigation of the Quenching Characteristics of a Salt Bath,** by M. J. Sinnott and J. C. Shyne, University of Michigan.

3:00 P. M.—**Limitations of the End-Quench Hardenability Test,** by A. R. Troiano and L. J. Klinger, Case Institute of Technology.

3:30 P. M.—**A Correlation of End-Quenched Test Bars and Rounds in Terms of Hardness and Cooling Characteristics,** by E. W. Weinman, R. W. Thomson and A. L. Boegehold, General Motors Corp., Research Laboratories Division.

Friday Morning, Oct. 19

Session on Physical Metallurgy

BUILDING M, FAIR GROUNDS

9:30 A. M.—**Particle Size Analysis of Metal Powders,** by C. C. Gregg and Bernard Kopelman, Sylvania Electric Products Inc.

10:00 A. M.—**Interrelation of Mechanical Properties, Casting Size, and Microstructure of Ductile Cast Iron,** by R. W. Kraft and R. A. Flinn, American Brake Shoe Co.

10:30 A. M.—**Gas Evolution From Gray Cast Iron During Enameling,** by L. F. Porter and P. C. Rosenthal, University of Wisconsin.

11:00 A. M.—**Aluminum, 6% Magnesium Wrought Alloys for Elevated-Temperature Service,** by K. Grube and L. W. Eastwood, Battelle Memorial Institute.

11:30 A. M.—**A Study of the Microhardness of the Major Carbides in Some High Speed Steels,** by P. Leckie-Ewing, Union Twist Drill Co., Butterfield Division, Canada.

*World Metallurgical Congress papers submitted by foreign conferees.

A New Process for Direct Reduction of Iron Pyrites

By Antonio Scortecci
Director
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and Massimo Scortecci
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In addition to the conventional blast furnace process, there are a number of other methods for the reduction of iron ore. The more successful of these include electric furnace reduction, iron sponge reduction, the Krupp-Renn process using rotary kilns, and reduction in a low-shaft furnace either with enriched air or not. These have been described by P. E. Cavanagh in "Alternative Iron Smelting Processes" in *Metal Progress* for May 1950.

From a general point of view, such processes may be considered as pilot plants making use of particular ores or deriving their advantage from local conditions. As such, they contribute in a minor way to world-wide industrial production, but are of great significance in gaining experience about methods of getting iron from its available ores.

High-grade iron ores are becoming scarcer all over the world; in several countries use of low-grade iron ores through concentration processes (often complicated and expensive) is being adopted. In view of this situation extensive research for new methods and new ores is being actively pursued.

Because iron pyrites are spread all over the world they probably represent the most suitable material to be considered for new experiments on iron reduction. Actually, pyrite cinders from sulphuric acid plants have been charged into blast furnaces for centuries. In many countries the practice has waned because so much acid is made from elemental sulphur, but the present shortage of such sulphur is again turning attention to the old, inexhaustible source. Even so, use of pyrites in this way, despite the cheap byproduct used for raw material, has two substantial drawbacks: First, the available quantity of pyrite cinders is set by the output of sulphuric acid plants and, second, pyrite cinders that have been roasted require another large input of energy to reduce them to elemental iron.

These facts make the development of a direct pyrite reduction process attractive.

One of the authors carried out experiments along these lines as early as 1925. The principle of the process consisted in the dissociation of pyrites in the absence of air, and in the presence of carbon, with the formation of iron and carbon disulphide. The sulphur content of the pig iron so obtained can be kept at low and technically acceptable values by methods dictated by economic conditions. Practically all the iron present in the pyrites is recovered as pig iron. The carbon disulphide, recovered from small-scale tests, contains as much as 60% of the original sulphur. Other tests showed that it is possible to separate directly some of the elemental sulphur.

Subsequent work was directed primarily to the study and design of larger equipment.

Early Experiments — The process was not originated by a systematic research directed toward the reduction of pyrites, but incidentally to some experiments comparing conditions under which the reactions

$$FeO + C = Fe + CO$$
$$2FeS + C = 2Fe + CS_2$$

may develop during gas extraction from steel heated under reduced pressure at a temperature near the melting point.

These tests were carried out in a carbon resistance furnace under reduced pressure, in an amorphous carbon crucible, originally on steel purposely enriched with sulphur, afterward on synthetic iron sulphide, and finally directly on pyrite mineral. The first experiments with pyrite were stopped shortly after melting occurred; carbon disulphide was given off and the solidified specimen in the crucible contained a button of iron with 2 to 4% sulphur and an upper layer of solid (mostly FeS) with 24 to 26% sulphur. When the melts were held at high temperature for a longer time, the upper layer disappeared and the sulphur content of the iron dropped to 1 to 2%.

Temperatures were estimated as 1700 to 1800° C. (3100 to 3275° F.); the pressure, from 5 to 1 mm. of mercury.

These preliminary results indicated that reduction of pyrites certainly was possible, so further tests were carried out in a small arc furnace (Fig. 1) lined with a carbon ramming mixture. Seventeen experiments made with this furnace went off easily and produced iron, carbon disulphide, and free sulphur.

Data on these runs are reported here:

Pyrite analyzing 46.4% Fe, 44.4% S and 7.3% SiO_2 was charged with coke into the cold furnace in the proportion of 90 parts pyrite and 7 parts coke. The operation could be followed by noting the production of CS_2 and by the shape of the flame (see Fig. 1). When no more sulphide was produced, three parts of lime were charged to the furnace. These runs yielded 5 to 6 lb. of iron from 15½ lb. of pyrite, 3.3 to 4 lb. of carbon disulphide and from zero to 1.3 lb. of sulphur (the latter being found in the pipe connecting the furnace to the condenser).

In some experiments, the remaining iron was cooled in the furnace; on complete cooling, both furnace walls and the iron mass were covered with a thick layer of beautiful lamellar graphite. On occasion this amounted to as much as 1¾ lb. The liquid carbon disulphide frequently was saturated with sulphur. The iron occasionally was gray but more often white. Its analysis ranged between the following limits: 3.9 to 4.3% total carbon, 0.04 to 0.13% manganese, 1.33 to 0.30% silicon, 0.017 to 0.022% phosphorus and 1.25 to 0.08% sulphur.

Figure 2 shows the fracture of some iron bars cast directly into refractory molds from the furnace, and Fig. 3 the fracture of a series of tensile specimens made on bars remelted in

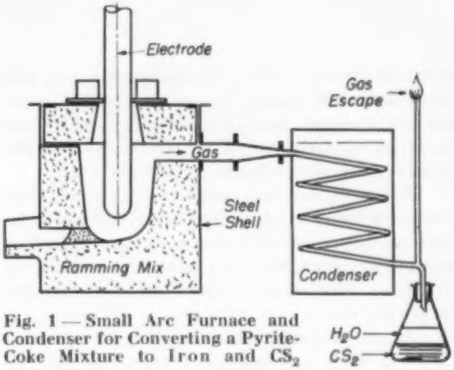


Fig. 1 — Small Arc Furnace and Condenser for Converting a Pyrite-Coke Mixture to Iron and CS_2

crucibles without any additions. Their analyses were 3.79 to 4.12% carbon, 0.04 to 0.07% manganese, 0.16 to 0.83% silicon, and 0.08 to 0.12% sulphur. Their ultimate tensile strength was 24,500, 26,600 and 28,400 psi. respectively. These were lowest in sulphur of the trial runs.

Further development of this process languished until 1939. At that time a second series of tests was performed with a similar furnace but large enough to take a 50-lb. charge. The 43 tests conducted during this period proceeded much as the previous ones, and were directed primarily toward obtaining an airtight furnace.

Analysis of the iron produced (without any additions) fell into the two groups: 1st GROUP — 4.5 to 4.2% total carbon, 0.25 to 0.60% Si, 2.8 to 4.3% S; 2nd GROUP — 4.5 to 4.2% total carbon, 0.70 to 2.22% Si, 0.94 to 1.60% S.

A third series of 40 experiments was carried out in 1941 with a tilting furnace of the same capacity, built specifically for the job. It had a single vertical electrode through the tight

Fig. 2 — Fracture of Round Bars Cast From Low-Sulphur Metal Made in Furnace of Fig. 1 (Full Size)

Fig. 3 — Fracture of Tensile Test Specimens Cast From Remelted Ingots Like Fig. 2

top; the pyrite-coke mixture was charged through one trunnion, the gases and CS_2 were led off through the other. A tap hole was arranged so metal could be removed when the furnace was tilted almost completely over.

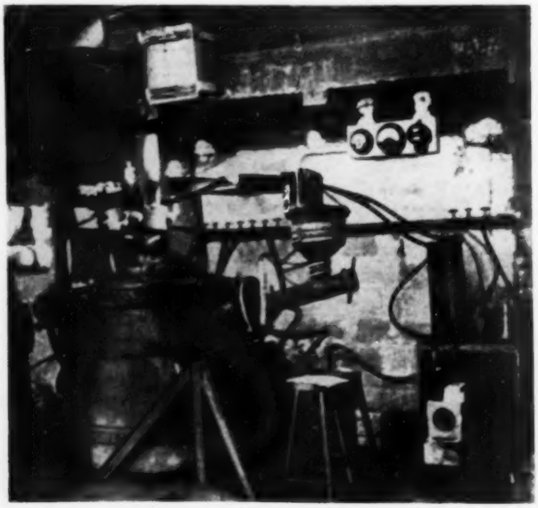
A fourth trial was made in 1943 in another factory with an existing ferro-alloy furnace suitably modified for charging and gas collecting. All of these experiments were hampered by shortages in power and other difficulties brought on by the war.

Again in 1947 a series of 45 tests was carried out with a tilting arc furnace holding 65 lb. of charge. This furnace is shown in Fig. 4. During this series all the data necessary were collected to design a larger furnace. The tightening of the electrode hole through the roof, the dust collection, and the condensation of carbon disulphide were done very satisfactorily.

The range of analyses of the iron obtained in these last experiments is 4.2 to 4.3% total carbon, 0.72 to 2.7% combined carbon, 1.20 to 0.60% Mn, 0.60 to 2.35% Si, 0.03 to 0.04% P, and 0.81 to 1.50% S. (The manganese in these irons is, of course, a result of the fact that the iron pyrite being smelted contained manganese in very considerable amounts.)

Silicon sulphide and flake graphite (the latter in amounts up to 8% of the cast iron) were found in the dust collector.

Fig. 4 — Tilting Arc Furnace, 65-Lb. Capacity, Used in Final Experiments. Gases are taken off through opening at upper edge of shell and passed through dust collector and condenser; the same opening serves as a tap hole. The pyrite reduced iron contained 0.81 to 1.50% sulphur



CHEMICAL REACTIONS IN THE PROCESS

Pyrite (FeS_2), heated in an oxygen-free atmosphere, partially dissociates to FeS, liberating a sulphur atom. The dissociation pressure reaches 1 atmosphere at about 760° C. (1400° F.). At higher temperature the FeS dissociates, also, liberating the second sulphur atom. Its dissociation pressure reaches 1 atmosphere at about 1780° C. (3235° F.).

In the presence of carbon, the following two reactions occur with the FeS and S, the above-mentioned products of dissociation.

$$S_2 + C \rightleftarrows CS_2 \qquad (1)$$
$$2FeS + C = 2Fe + CS_2 \qquad (2)$$

Some carbon also dissolves in the iron.

Reaction (2) depends on the pressure of CS_2, and this in turn depends upon the dissociation of CS_2 — reaction (1) — which is temperature dependent. Thus, dissociation of FeS_2 begins about 800° C. (1475° F.); near the melting point of iron, around 1500° C. (2730° F.), the concentration of CS_2 in the gaseous phase is very low. Between 800 and 1700° C. the sulphur vapor is surely biatomic, since dissociation of the biatomic molecule does not start until about 2000° C.

The process actually is controlled more by the kinetics of the reactions than by their equilibrium behavior. The desulphurization of pyrites at high temperature can therefore be explained as follows:

At first, the pyrite dissociates, loosing its first sulphur atom, according to the reaction $2FeS_2 \rightleftarrows 2Fe + S_2$. This sulphur combines with carbon as in reaction (1). The resulting carbon disulphide is quickly driven away from the reaction zone and is eventually condensed outside the furnace. (Depending upon defects of the furnace, part of the sulphur may condense as such, avoiding any reaction with carbon.)

As the remaining iron sulphide (FeS) melts, contact with carbon improves, and reaction (2) starts; iron separates as the heavier constituent and becomes saturated with carbon. Two liquid layers appear, the bottom one being metallic iron with carbon and sulphur in solution, and the lighter upper layer being iron sulphide (FeS) which acts as a kind of

slag holding very small amounts of dissolved carbon. Sulphur and carbon concentrations in both layers have been determined as temperature functions by A. Norro and S. Lundquist in an article published in *Jernkontorets Annaler*, 1946, p. 188, entitled "Miscibility Gap in the Fe-S-C System Between 1300 and 2000° C."

If these reactions were the only ones to occur we could not explain why our experimental results do not agree with the sulphur concentration in the metallic phase reported by Norro and Lundquist. The difference may be due to the presence of silicon, which modifies desulphurization by a series of reactions occurring in the gaseous, slag and metallic phases. These reactions may run as follows:

$$SiO_2 + 2C = Si + 2CO$$
$$SiO_2 + FeS = (SiFe) + SO_2$$
$$SiO_2 + 2C + FeS = Fe + SiS + 2CO$$

In the gaseous phase, CO and SO_2 must form volatile products with sulphur such as COS. (These were in fact observed by us in the various experiments.) Silicon also modifies the position of the miscibility gap in the Fe-S-C system, the equilibrium concentration of sulphur being decreased in the metallic phase.

Silicon thus plays an important role in the present process, and the simultaneous presence of lime further decreases the sulphur content in the metallic phase.

POWER REQUIREMENTS

To estimate the power requirements we assume the main reactions to be as follows:

$$2FeS_2 = 2FeS + S_2 - 37 \text{ Cal.} \quad (1)$$
$$2FeS = 2Fe + S_2 - 80.6 \text{ Cal.} \quad (2)$$
$$C + S_2 (\text{gas}) = CS_2 + 12.5 \text{ Cal.} \quad (3)$$
$$2FeS_2 + C = 2FeS + CS_2 - 24.7 \text{ Cal.} \quad (4)$$
$$2FeS + C = 2Fe + CS_2 - 68.1 \text{ Cal.} \quad (5)$$

Specific heats are also as follows: FeS_2 = 0.22 from 0 to 1200° C.; liquid CS_2 = 0.242 at 18°C.; mean specific heat of iron = 0.16. Reaction (4) is complete at about 800° C.; reaction (5) starts at about 800° C. and is complete at about 1800° C.

Computing the thermal requirements from the above data, 182 Cal. are necessary to liberate 2 gram-atoms of iron.

The best way to evaluate this figure is to compare it with electric furnace reduction of ore, which is similar in operation and equipment. The reaction is

$$Fe_2O_3 + 3C = 2Fe + 3CO - 117 \text{ Cal.}$$

Since the products enter at room temperature and come out at 1600° C. (2900° F.), the total amount of necessary heat, calculated as in the desulphurization reaction, comes to about 194 Calories.

These theoretical figures are closely comparable in the two processes, so it is safe to estimate that the reduction of pyrites will require about as much energy as the electric furnace reduction of ore, which is about 2700 to 2800 kw-hr. per ton of iron.

INDUSTRIAL POSSIBILITIES

While complete knowledge of the theory of this new process needs considerable research, the technological possibilities seem firmly established by our experiments.

While our five series of experiments did not give any new knowledge of the chemical process beyond that gained at the first, they revealed many shortcomings in the equipment which were overcome. We are sure that a plant of industrial size could be constructed with equipment that is standard in present-day metallurgical and chemical industries.

Iron yields in our tests have been higher than 95%. Sixty per cent of the sulphur is recovered as carbon disulphide or sulphur; losses are attributed to leaks in the experimental equipment with consequent formation of oxysulphides, to the formation of silicon sulphide from silica in pyrite gangue and in coke ashes, to the formation of small amounts of sulphides by the other metallic elements in the pyrite, to moisture in the charge — which forms H_2S and oxysulphides, and to the dusting of FeS during the early stages of FeS_2 dissociation.

The process appears economically feasible on the basis of present prices of raw materials and power, but such calculations are necessarily open to error. It appears safe to say, however, that it is an interesting procedure, auxiliary to the classic oxide reduction, mainly because it supplies iron directly from ore, independently of sulphuric acid plants. Any byproduct sulphur would have an immediate market under present conditions. On the other hand, the amount of CS_2 obtained with even a modest production of iron would exceed the present market. This could be side-stepped by burning the CS_2 in a limited amount of oxygen, thus producing elemental sulphur, or by developing organic products derived from CS_2. The latter possibility is favored by its large free energy compared to that of hydrocarbons.

Lastly, any byproduct graphite would find a ready market in several industries.

The "Onera" Bright Chromizing Process

By Bernard Jousset
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THE PRINCIPLE of improving the surface properties of metallic objects by diffusion is far from new; its classical examples are case hardening and nitriding. The formation of a diffusion layer rich in chromium is more recent and only beginning to come into industrial use. With the need for stainless steels increasing in every branch of industry, together with the present dearth in chromium, the future for chromizing appears promising.

Because corrosion is a surface reaction only, it can be prevented by modifying a minimum thickness of the bulk material by means of chromium diffusion. This method has the double advantage of saving up to 95% chromium, and avoiding the machining difficulties encountered with stainless and high-chromium steels.

Another advantage is that the chromium content of the surface layer can run as high as 50% to give better corrosion resistant properties than are obtained in ordinary stainless steels.

Perfectly regular, smooth, and bright layers are obtained in a single operation with the new chromizing process developed and patented at the ONERA (Office National d'Etudes et de Recherches Aeronautiques). These layers are highly resistant to corrosion caused by atmosphere, salt, nitric acid and high temperature. No layers can peel or scale off from thermal or mechanical shock, as can happen with electrolytic plating, because the surface layer is an integral part of the basis metal.

CHROMIZING PROCESS

Many chromizing processes have been proposed but, in general, they are too complicated to be practical and produce a defective surface. In the Onera process, gaseous chromium fluoride decomposes or "cracks" at the surface of the steel parts, the chromium diffuses into the metal, and the hydrofluoric acid recombines with chromium chips that are packed in with the steel articles.

Chromium is packed either near or in direct contact with the steel parts. A chromium fluoride-producing mixture of pulverized chromium, alumina, hydrofluoric acid and ammonium fluoride is kept separate from the work. The whole pack is heated in a reducing atmosphere under slight pressure. An alternate method consists in heating the fluoride mix separately. In either case, chromium fluoride is given off at 210 to 480° F. according to the equations:

$$NH_4F \rightarrow NH_3 + HF$$
$$2HF + Cr \rightarrow CrF_2 + H_2$$

At about 1550° F. the vapor pressure of the chromium fluoride is high enough for the chromium to diffuse into the metal. A true gaseous cementation of chromium with a chromiferous gas is thus obtained. In one hour at 2010° F., chromium will give a 0.1-mm. (0.004-in.) surface layer that is both homogeneous and ductile. Layers up to 1 mm. (0.040 in.) in thickness have been built up.

Average hardness of these surface layers runs around Vickers 200. The chromium content, as determined by spectrographic analysis and successive electrolytic polishings, was found to exceed 50% at the surface of the material and decrease gradually toward the inside.

With high-carbon steels and cast irons, the carbon reacts with the chromium and diffuses toward the surface to give a continuous layer of chromium carbide. Although the layer formed after 4 hr. at 1920° F. is only 0.03 mm. (0.0012 in.) thick, it has a hardness of Vickers 800 to 1000. Special steels containing "carbide formers" (titanium, manganese and molybdenum) have been prepared in Germany for use with the B.D.S. chromizing process. The Onera process gives as good results with ordinary steels as with these special steels.

Such refractory metals as tungsten or molybdenum require higher temperatures, 2730 to 2910° F., because the diffusion coefficient of chromium is very low in these metals. Refractory metal powders can be chromized in the gaseous phase between 1920 and 2010° F.

The chromizing mixture does not deteriorate during use, although a small quantity of fluorous compound must be added between operations. Ammonium chloride and other ammonium halides

are not recommended for this process as they pit the steel. These pits are probably due to volatile iron chloride produced at the beginning of the process. On the other hand, ammonium fluoride gives a very thin protective layer of iron fluoride, which is not volatile at all and is reduced by hydrogen at high temperatures. Lastly, chromium fluoride has the advantage over ammonium chloride of being nonhygroscopic.

FIELDS OF APPLICATION

Chromium diffusion layers obtained by gaseous chromizing are corrosion resistant. Chromized specimens treated for a few hours at 1920 to 2012° F. are not pitted after several weeks of intermittent immersion in salt water. Onera chromizing produces a decorative surface suitable for such applications as marine fittings and motor car trim.

The following properties of Onera chromizing on steel and cast iron indicate its scope of applications:

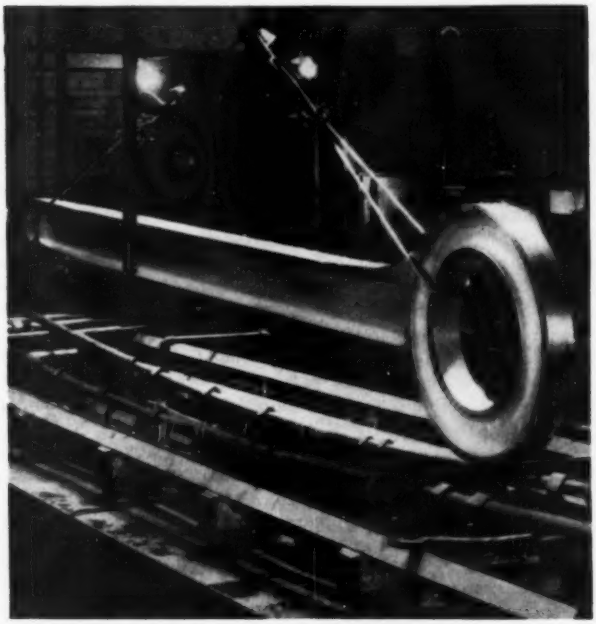
1. Chromized steel may be subjected to severe shaping operations without the diffused layer scaling off or splitting.
2. Chromized steel can be electropolished or electroplated with chromium.
3. Chromized layers on mild steel are highly wear resistant. The low hardness obtained with low-carbon steels can be improved with a complementary nitriding.
4. Chromized layers on high-carbon steels and cast irons are less ductile but are extremely hard because of the large amounts of chromium carbide found in the case.
5. Chromizing temperatures may warp or deform the parts being treated, which is a limitation to the process. The mechanical properties of the metal may also be altered during chromizing, thereby necessitating a subsequent heat treatment.

Both superficial oxidation and chromium diffusion into the interior limit the maximum temperature at which chromized layers can be used. Dry tests in flue gases show that the lifetime of homogeneous 0.1 to 0.15-mm. (0.004 to 0.006-in.) chromized layers is practically unlimited up to roughly 1380° F. At 1470 to 1560° F., they can be used for several hundred hours, but at 1830 to 2010° F. the layers disappear after a few hours. Thermal shock resistance is excellent because of the gradual transition in properties from layer to core.

Chromizing can also be used to protect nickel, cobalt or alloys such as Hastelloy (which contains no chromium) against scaling at temperatures to 1650° F.

Scale resistance can be improved by producing binary or ternary layers containing (in addition to chromium) silicon, aluminum or tungsten. These elements, or their compounds, are added to the fluoride mix where they react with the chromium halide to give their corresponding halides which take part in the gaseous cementation. These additions, made under the same operating conditions, improve the composition and thickness of the layers, as well as increase the maximum scale-resistant temperature.

Resistance to liquid nitric acid attack is excellent, while against attack by nitrous oxides at high temperature is very good. The 0.004 to 0.006-in. thick layers will resist more than 1 hr. exposure to these gases at 1830° F.



Chromium Plating a Locomotive 12-Ft. Main Rod. One of the biggest plating jobs tried, temperature of work and bath were controlled to give uniform coating. Courtesy Timken Roller Bearing Co.

Bessemer Steel Low in Nitrogen and Phosphorus

By Pierre Coheur
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Liege, Belgium
Director, Liege Section
National Bureau of Metallurgical Research

While for many applications, such as screw machine parts, rail, structural steel and concrete reinforcement, basic bessemer steel is just as suitable as openhearth, it cannot compete with the latter in uses requiring high ductility — for example, deep drawing.

For over half a century European steelmakers have tried to overcome this disadvantage by reducing its nitrogen and phosphorus content. This can be done by carefully controlling the temperature, blowing pressure, and time of operation. By such methods, Belgian works regularly produce basic bessemer with nitrogen as low as 0.007 to 0.012% and phosphorus as low as 0.050%.

To reduce the nitrogen further in a bottom-blown vessel, the metal may be blown with oxygen-enriched air or other gases. The present paper will give a brief account of this process and the results obtained.

The development work was done in three Liege steelworks: S. A. Ougrée-Marihaye, S. A. Métallurgique d'Espérance-Longdoz, and S. A. John Cockerill, and included experiments with the converters themselves, extensive chemical analyses and physical tests of the steels produced and a statistical study on more than 400 test blows — that is, on more than 8000 tons of metal.

Tests With Enriched Air — The first tests were undertaken to define the optimum conditions for eliminating nitrogen by blowing with oxygen. To this end, the amount of oxygen in the blast or the charge, the nature, the quantity and the time of the additions were varied.

1. With an air enriched to 30% oxygen (which seems to be economic optimum) and with nothing but scrap additions for cooling the steel bath, nitrogen was reduced 20% from the value obtained with normal practice — that is, from 0.0100% (normal) to 0.0083% with enriched blast.

2. With the same air enrichment (enough oxygen added to bring it to 30%), but cooling the bath with ore additions instead of scrap, nitrogen was lowered 40% — that is, to 0.0060%.

3. Nitrogen content in the steel can be reduced by charging or blowing a substance such as a carbonate, which decomposes with heat and evolves a gas, thus lowering the partial pressure of nitrogen in the blast. Ordinary limestone is most suitable for such an addition. Besides being cheap, it decomposes to sulphur-free CaO. Furthermore, the CO_2 evolved partially decomposes to CO and O_2, and this oxygen helps shorten the conversion time.

To study the effect of limestone, a number of blows were made with ordinary air and with increasing amounts of limestone, in which the amount of burned lime and scrap was reduced in the same proportion that limestone was added. When these results were plotted and an average curve drawn, it was found that little or no nitrogen would be eliminated unless more than 40 lb. of limestone per short ton of pig iron was charged; 100 lb. of limestone reduced the normal nitrogen by one quarter; one half elimination required about 300 lb. limestone per ton of pig iron. (It may be assumed that, in these runs, 40 lb. of limestone per ton of pig was lost by dusting, delayed action, or other causes.)

While the CO_2 from $CaCO_3$ acts chiefly by reducing the partial pressure of N_2 in the blast, this action is completely independent of other

Table I — Blows With Steam-Oxygen-Air

Blow	H_2O-O_2 Mixture	O_2 Consumption*	Scrap Addition†
4 min., 30% O_2 air; 4 min., H_2O-O_2 mixture added	63% O_2; 37% H_2O	1350 to 1475	34 to 38%
	70% O_2; 30% H_2O	1540	75%
30% O_2 air plus H_2O-O_2 mixture	63% O_2; 37% H_2O	1765	None
	70% O_2; 30% H_2O	1860	60%

*Cu.ft. per short ton pig iron blown; total for entire blow.
†Based on pig iron charged to converter.

details of the process, such as enriching the air and making ore additions. Consequently, definite advantages should be obtained by combining all of these methods. Experiments confirm this. With air enriched 30%, and with ore (no scrap) plus 2600 lb. of limestone charged to the converter instead of 1650 lb. of lime, nitrogen in the resulting steel was 35% below that remaining after a blow with enriched air and ore only. This means that basic bessemer steel has been produced with a nitrogen percentage of 0.0040%, and this is comparable to openhearth steels.

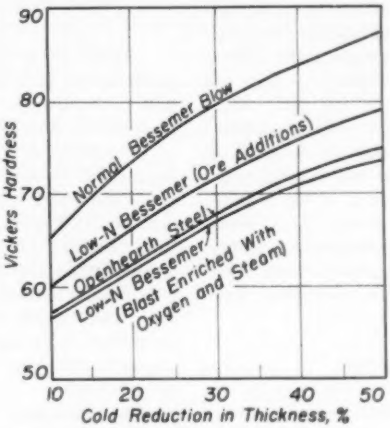

Fig. 1 — Normal Bessemer Steel Hardens Considerably More, for a Given Amount of Cold Reduction, Than Low-Nitrogen Steels

Phosphorus can also be reduced 30% by enriching the air in oxygen and using ore and limestone. Normal basic bessemer contains 0.050% P; the revised process makes steel with 0.032% P. Any further reduction involves a double slag process, requiring a higher temperature at the end of the blow, and this automatically adds 0.0010 to 0.0020% to the nitrogen in the resulting steel.

Production Rate — An important economic gain is possible. Oxygen-enriched air means that additional scrap or ore can be melted, and conversion time can be cut by about 40%. Increase in production of a 15,000-kg. converter can average 20 to 25% when air enriched to 30% oxygen is used.

These important advantages were predicted on theoretical grounds more than 25 years ago and have since been experimentally verified.

TESTS WITH STEAM AND OXYGEN MIXTURES

If the very lowest nitrogen is desired in the steel, other methods must be used, such as blowing with mixtures of oxygen and nitrogen-free gases. Superheated steam, which some steelmakers have used for controlling the temperature during conversion, is the most economical gas for dilution.

The first tests using steam and oxygen immediately showed a reduction in the ejection losses, reduced the nitrogen content to about 0.0020%, and cut the conversion time 40 to 50%. Furthermore, scrap additions could be increased approximately in proportion to the ratio of steam to oxygen.

Numerous tests led to two preferred processing methods: The first attempts to reduce the oxygen costs utilized the steam-oxygen-air mixture only during its most effective period — that is, from the middle of the decarburizing period to the end of the conversion. The first half of the blow is best done with air enriched to 30% O_2, which allows appreciable scrap and ore additions.

The second method attempts to reduce ejection losses by starting the steam-oxygen-air mixture as soon as metal is spit from the converter mouth, or by using the mixture from the very start of the blow. This permits the charging of pig iron that could not be blown with ordinary air because it would then fail to develop the necessary heat. Ultimately it may be possible to operate the blast furnace so as to obtain pig iron richer in silicon and lower in sulphur.

Steam and oxygen mixtures thus offer

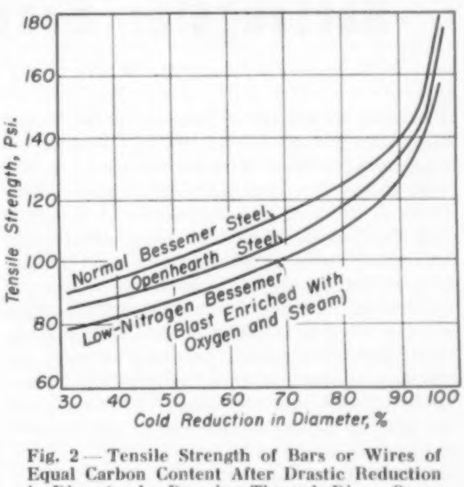

Fig. 2 — Tensile Strength of Bars or Wires of Equal Carbon Content After Drastic Reduction in Diameter by Drawing Through Dies. Openhearth steel is intermediate in hardness between normal basic bessemer steel and low-nitrogen steel made by special bessemer process

exceptional economic possibilities, not only in the basic bessemer process but also in the acid.

The phosphorus in steel produced by either method is of the order of 0.035% — that is, about the same as obtained in the tests with enriched air. But, in contrast with the blows using enriched air, a second slag can be used if the vessel is blown with steam and oxygen mixtures without increasing nitrogen in the resulting steel. Basic bessemer steels have been produced without difficulty containing about 0.0020% nitrogen and 0.020% phosphorus. The slags have lower iron contents, indicating less oxidation of the metal.

PHYSICAL PROPERTIES

These steels have been tested in ways too numerous to describe here at length. Improvement in ductility, which was the original object of this research, is obtained. Figures 1 and 2 on p. 79 show that steels produced by the methods described briefly in this article have properties comparable to or better than values for normal openhearth steels.

CONCLUSIONS

These tests indicate that blowing with enriched air or a mixture of steam and oxygen will produce basic bessemer steels with exceptionally low nitrogen and phosphorus.

Ductility of these steels is excellent — at least equal to normal openhearth steel.

From the point of view of economies, these methods of blowing offer outstanding possibilities. Besides insuring a product of excellent quality, they increase the production capacity of standard bottom-blown converters. Further, they convert pig irons of compositions which heretofore were either difficult to blow in the conventional way or which did not generate enough heat.

In conclusion, it must be said that these results are in large part due to the splendid teamwork of Messrs. Danbersy, de Radiquès, and Peeters of the S. A. Métallurgique d'Espérance-Longdoz; Messrs. Marbais, Hotot and Poverman of the S. A. d'Ougrée-Marihaye, Messrs. Van Campenhout, Nepper and Dor of the S. A. John Cockerill.

Drawing Limits for Rectangular Boxes

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Billions of pounds of strip are press formed each year throughout the world. Despite the tremendous volume of metal fabricated in this way, there is no systematic knowledge of the limits of the many press operations. It is true that the drawing of circular cups is reasonably well understood. In addition to a large number of facts obtained from extensive theoretical and experimental research on this operation, there are two rules of thumb that have been successfully used by shop-men for many years: *(a)* Circular cups can be drawn successfully in production from most commercial sheet metals if the ratio of the blank diameter to cup diameter is less than two, and *(b)* if the height of the circular cup does not exceed its diameter.

On the other hand, information on the limits for cupping rectangular shells — an operation commonly encountered in production — is virtually nonexistent. The present report gives some data on the subject in an effort to correct this situation. It confines itself to a study of the geometric variables involved in drawing rectangular boxes of normal deep drawing grade of aluminum sheet. Such variables as metal properties, heat treatment, hold-down pressures, press speed, or lubricant which affect the drawing limits have been held constant.

Procedure — The experiments were carried out on 99.5% pure aluminum strip at two thicknesses: 0.8 and 1.0 mm. (0.031 and 0.039 in.). The material had been hot rolled to 4.0 mm. (0.157 in.), cold rolled to final thickness, and annealed at 350° C. (660° F.) for 1 hr. Using Fukui's cupping test,* the maximum blank diameter that could be drawn without tears was

*In the Fukui test a round blank is cupped through 60° conical die using a spherical punch with diameter of 17.46 mm. (0.68 in.) and a die having a diameter of 19.95 mm. (0.78 in.). The nose radius of the "cylindrical" punch is 4 mm. (0.157 in.) and that of the spherical punch is equal to half the punch diameter.

2.48 and 2.45 times the cup diameter for the cylindrical and spherical punches, respectively. The ordinary or commercial grade aluminum strip gives values of 2.44 to 2.50 in this same test; therefore the present stock can be regarded as normal deep drawing material.

The principal dimensions of the punches and dies for the rectangular boxes were chosen to fall within common practice. These dimensions (shown in Fig. 1) include corner radius of the punch C, the bottom radius of the punch B, the bottom radius of the corner of the punch D, the shoulder radius of the die D_s, the radius at the corner of the die D_c, the width of the punch W and the length of the punch L. Their actual values in these experiments are listed in Table I. (Note that in most instances C is greater than B, so that the vertical projection of the center of radius C falls upon the flat bottom of the box.) The clearance maintained between the punch and die was between 1.0 and 1.1 times the original thickness of the sheet.

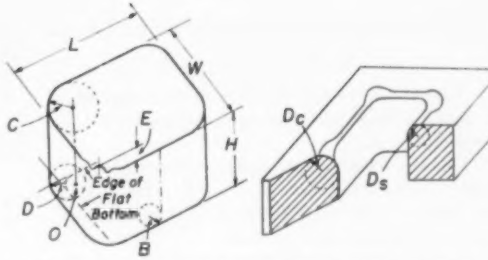
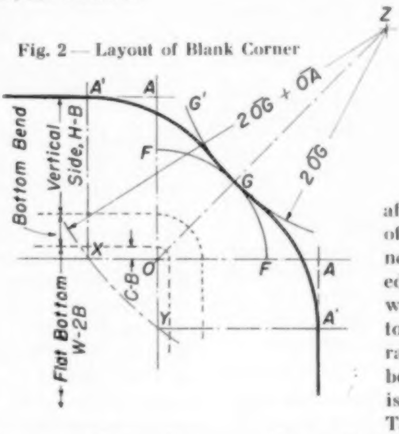


Fig. 1 — Left, Dimensions of Punch (and Resulting Shell); Right, Dimensions of Die. H is the total height of cup; the height of the vertical side is H-B

Fig. 2 — Layout of Blank Corner



The press we used was a crank drawing press with a cam-actuated blank holder. Thus, blanks were held rigidly and changes in thickness of cup-wall were less than would have occurred if the blank were held down by springs or rubber blocks. Press capacity was 55 tons, the working stroke was 19½ in. and the press operated at 20 strokes per min. The lubricant used in the study was a mineral oil mixture.

The shape of the blank's corner is quite important in drawing rectangular boxes; it not only affects the cupping limit (depth of cup), but determines the evenness of the box height and top edge. The shape adopted by us was thought to be well adapted to large variations in the corner radius of the punch. (C varied between 11 and 40 mm. — that is, $\frac{7}{16}$ to $1\frac{9}{16}$ in., as shown in Table I.)

The method of laying out the blank profile is shown in Fig. 2. Point O is the vertical projection of the center of the corner radius C. $\overline{OG}$ should theoretically be the radius of a circular blank which would form into a cylindrical shell of 2C diameter, domed bottom of D radius and total height of H (assuming the surface area of the blank equals the surface area of the resulting shell). This radius $\overline{OG}$ can be computed from the formula $\overline{OG}^2 = 2C(H-D)+C^2+C(\pi-2)D+(3-\pi)D$ when C is equal to or greater than D.

The dimension so computed proved to be 5 to 10% deficient. That is to say, when blanks were laid out with computed dimension $\overline{OG}$, there was a deficiency of metal at the top corner of the box, rather than a slight ear as shown at E, Fig. 1. Consequently, after the first trials the computed $\overline{OG}$ was increased by 5% for cups with C = 11 to 15 mm. (Table I), and 10% for cups with C = 30 to 40 mm. $\overline{OG}$ (a line at 45°) was extended for the center of curve GG'; its radius was $2\overline{OG}$.

Table I — Dimensions (in Mm.) of the Punches and Dies Sketched in Fig. 1

Combination	Punch (Shell)					Die	
	C	W	L	B	D	D_s	D_c
No. 1	11.0*	99.0	99.0	9.0	9.0	5.0	7.5
2	11.2*	106.4	171.4	9.2	9.2	5.0	7.5
3	12.0*	136.0	176.0	10	10	5.0	7.5
4	15.0*	126.0	184.0	15	15	5.0	7.5
5	40.0*	205.0	435.0	15	15	5.0	7.5
6	30.0†	60.0	105.0	10	10	8.0	8.0
7	30.0†	60.0	75.0	10	10	8.0	8.0
8	30.0*	100.0	100.0	12.5	12.5	5.0	8.0
9	30.0*	100.0	120.0	12.5	12.5	5.0	7.5
10	30.0*	100.0	150.0	12.5	12.5	5.0	7.5

*Tools of these dimensions used with 0.8-mm. (0.031-in.) sheet.
†Tools of these dimensions used with 1.0-mm. (0.039-in.) sheet.

$\overline{OA}$ was similarly computed from the formula

$$\overline{OA} = H + C - \left(2 - \frac{\pi}{2}\right) B$$

Centers X and Y for the curves tangent at A′ were located by striking a radius $2\overline{OG} + \overline{OA}$ from center Z.

Blanks laid out by these principles were made progressively larger — that is, with increasing values of H (total height) — for each punch-and-die combination of Table I. The limit of deep drawing for these studies was the occurrence of tearing of the box at or near the bottom.

The results of our cupping tests may be plotted in various ways. In Fig. 3 the vertical

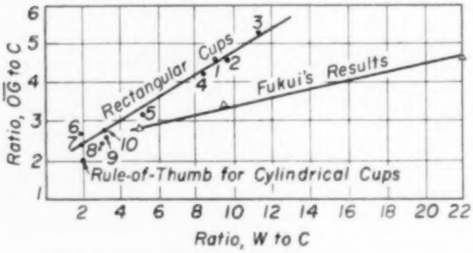


Fig. 3 — Cupping Limit in Relation to Radius at Corners (Intersections of Sides)

ordinates are $\overline{OG}/C$, the ratio between the radii at the corner of the blank and at the corner of the punch; the horizontal ordinates are W/C, the ratio between the width of box and the corner radius of the punch. A circular cup can be described as one wherein W/C = 2; a solid circle is shown in Fig. 3 and 4 at X = 2, Y = 2 which corresponds to the rule-of-thumb limiting value for such a shape.

The location of two of our experimental points for punch-and-die combinations (Table I) have the same abscissas but show higher cupping limits than those indicated for the rough rule. These cups were not circular cups but rectangular boxes with cylindrical bottoms — that is, the box's width was equal to 2C, but the length was greater than 2C. It is possible that the higher cupping limit for these combinations No. 6 and 7 may be due in part to the lateral flow of metal from the circular ends into the sides of the box. The general increase in cupping limit as the ratio of box width to punch corner radius increases is undoubtedly due to the same effect.

Some results of Fukui, Takeyana, and Yoshida are also plotted in this graph. The

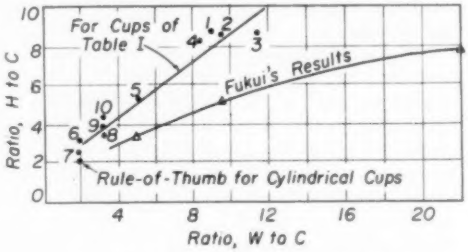


Fig. 4 — Cupping Limit as a Function of Height and Width of Square Box

corner-bottom radius D of their punch, and the corner-shoulder radius D_c of their die were much smaller (being about 5 mm. or 0.2 in.) than those used in the present experiments. The different lines on Fig. 3 indicate that these radii are also determinative variables for the cupping limit for rectangular boxes.

Figure 4 plots the results in a different manner. Here the ratio of the successful box height H to the corner radius of the punch C is plotted as a function of the ratio of the box width W to the corner radius of the punch C. Inasmuch as the denominators of these two ratios are the same, they can be canceled out, whence it is seen that the present results could be described most simply by saying that the maximum attainable height of the box is about equal to the width of the box. This would appear to be a simple extension of the approximate rule for cylindrical cups, namely, that its height cannot exceed its diameter.

However, the results of Fukui and his co-workers plotted on the same figure warn against any such hasty conclusion, and again emphasize the importance of the corner-bottom radius on the punch and the corner-shoulder radius on both punch and die.

It should be pointed out that these data involving box height are not accurate because of the inevitable waviness of the top edge of the box; however, they will provide a reasonably adequate guide for approximate layout work.

High Permeability "Sendust" Powder Ring Cores

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"SENDUST" is a high permeability alloy discovered by Honda, Masumoto and Yamamoto in course of an investigation of the magnetic properties of the iron-rich iron-silicon-aluminum alloys.

Use of the alloy in powder form for loading coil cores seems to have been developed over the period 1937-1940, but little was known of this activity until the visits of United States and Australian scientific missions to Japan in late 1945 and early 1946, respectively. It was then found that, owing to the extreme shortage of nickel, Sendust had been used to the virtual exclusion of Permalloy for voice and carrier frequency applications. The material is also reported to have been used to a limited extent in Germany toward the end of the war where it was produced by Siemens and Halske who, it is claimed, preferred it to high nickel-iron alloys.

If the scanty post-war references to Sendust are any indication, little or no interest has been shown in the material, except possibly in Russia. The few writers who have mentioned it at all are inclined to dismiss it from further consideration on the grounds that the composition is very critical, that the permeability of the finished cores is appreciably lower than of the high nickel alloys, and that the loss coefficients are appreciably higher; the only factor mentioned in its favor is that, being a brittle alloy, it is readily crushed to powder.

With nickel in reasonably free supply, Sendust may never be an attractive substitute for high nickel alloys; on the basis of present indications, however, nickel, is likely to become increasingly restricted to critical applications for which no satisfactory substitutes are available and the author believes that now is the time to explore the potentialities of any promising substitutes. Sendust is considered to fall within this category of an alternate material.

The reader is asked to bear in mind that the work on which this note is based is purely exploratory and would not be reported at this stage but for the incentive provided by the Metals Congress. The purpose of this note is to draw attention to what appears to be a neglected opportunity for saving nickel.

PROPERTIES OF SENDUST

According to Masumoto's description in his report "On a New Alloy 'Sendust' and Its Magnetic and Electrical Properties" (published in Anniversary Volume of the Science Reports of the Tohoku Imperial University, Series I, 1936), the initial permeability of the iron-rich Fe-Si-Al alloys reaches a sharp peak value of 35,000 at 9.6% Si and 5.4% Al; the peak value of 160,000 for maximum permeability is reached at 9.7% Si and 6.2% Al (see Fig. 1 and 2, reproduced from Masumoto's paper). Hysteresis loss of the alloy in bulk form was quoted as 28 ergs per cc. per cycle at a peak flux density of 5000 gausses and resistivity at 81.2 microhm-cm., as compared with 73 ergs per cc. and 16 microhm-cm. for Permalloy.

A striking feature of the curves relating permeability with composition is the extremely rapid fall in both μ_o and μ_{max} with departure from optimum composition. At first sight, it would seem that the alloy composition might be too critical for practical application. In powder cores, however, the effective permeability (due to insulating material between the particles) is only a very small fraction of the intrinsic permeability of the starting material, and it is a matter of experience that intrinsic permeabilities much lower than optimum are still capable of giving powder cores with acceptable characteristics. An initial permeability of 10,000 is understood to be accepted in Japanese works practice as being very satisfactory; rejection limit is believed to be 6000.

The only information available in Australia regarding typical properties of powder cores is that contained in the Australian Scientific Mission to Japan, Report No. J 261, translation of a paper by Yamamoto. The values shown in Table I are from this report.

Australian results on Japanese ring cores are even more scanty, only two cores having been available for test; the results on these

samples are shown in Table II, in which has been included for comparison the corresponding figures for two randomly selected Permalloy cores of similar dimensions.

It is obviously unsound to draw any definite conclusions from such a limited number of results; the figures, however, are generally in line with the published data given in Table I and (at least for the lower permeability core) they compare quite favorably with the particular Permalloy comparison core.

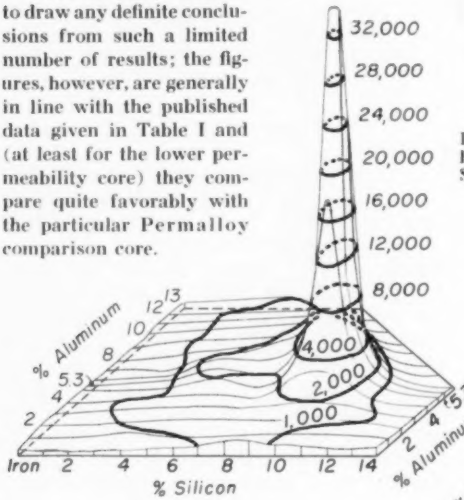

Fig. 1 — Initial Permeability of Iron-Rich Iron-Silicon-Aluminum Alloys

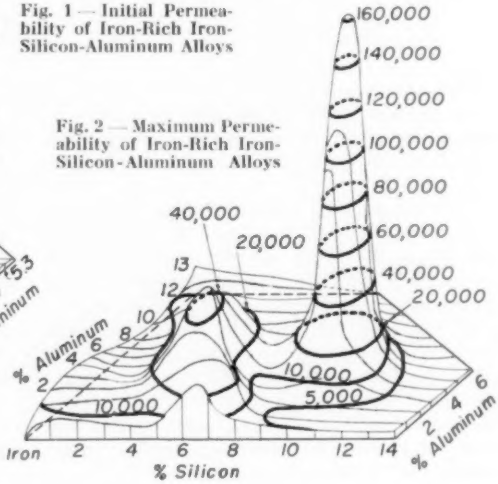

Fig. 2 — Maximum Permeability of Iron-Rich Iron-Silicon-Aluminum Alloys

EXPERIMENTAL WORK

The work described falls in the preliminary stage of an investigation to establish a manufacturing technique for Sendust powder cores, having a permeability within the range of 80 to 90 coupled with acceptable loss factors, for use in loading coils for voice frequencies and transmission network applications generally.

It was clear at the outset that the factors affecting the properties of finished cores were numerous and interconnected. Therefore, it would not be reasonable to investigate each variable independently and in detail until a preliminary survey had been made and a procedure established that would give cores with properties at least within sight of the objective.

For convenience, the order of presenting the description of this survey follows the sequence of the manufacturing operations involved in making the cores. Because of the short-cut methods adopted, the results obtained in the early stages were often affected by more than one variable and, as they could easily be more confusing than helpful to the reader, they have been omitted. Detailed results★ have been given for work carried out toward the end of the survey, at which time the general pattern of behavior became clearer and it was feasible to limit the number of variables under investigation at one time.

Melting — Japanese practice is to melt in quantities up to 1000 lb. in an induction melting furnace of 200 or 300 kva. capacity. The iron is melted first, quickly brought to 1600° C., and a lime slag cover is established by the simultaneous addition of lime with the silicon, which is added progressively in small quantities. The aluminum is added as soon as possible, and is plunged to the bottom of the melt to minimize oxidation losses. Total time from melting of the iron to completion of the additions should not exceed

Table I — Typical Properties of Sendust Ring Cores

Permeability	Hysteresis Loss Coefficient	Eddy Current Loss Coefficient
13	4.5	0.14
20	11.0	0.13
31	14.3	0.07
36	16.0	0.08
50	14.3	0.06
56	35.4	0.13
56	21.4	0.16
60	35.4	0.19
64	57.0	0.28
70	42.7	0.18
72	57.0	0.47
79	67.6	0.42
80	71.2	0.57
89	62.3	0.45

★Hysteresis and eddy current loss coefficients. Residual loss coefficients have not yet been determined.

Table II — Test Results on Sendust and Permalloy Cores

Core	Permeability	Hysteresis Loss* Coefficient	Eddy Current* Loss Coefficient
Sendust	53	30	0.53
Sendust	66	75	1.28
Permalloy	55	35	0.61
Permalloy	92	65	1.61

*All of these tests were carried out by the Research Laboratories of the Postmaster-General's Department.

15 min.; optimum time is about 5 min. As a control, a ring is cast and tested magnetically; extra aluminum is added if the permeability is low. The iron used is an electrolytic grade; the purity of the silicon and aluminum does not appear in any reports available to the author.

Our initial melts (which were of 2 to 3 lb.) confirmed the difficulties of melting the alloy on a small scale without undue losses of both silicon and aluminum. As was expected, melting in vacuum was quite successful but was discarded as being a method not likely to be acceptable to Australian industry. The method finally adopted was to melt under hydrogen, using an inverted crucible as a cover, followed by degassing for 2 to 3 min. with argon. Losses of silicon and aluminum were negligible.

Raw materials for the experimental melts were ingot iron (0.03% C, 0.014% P, 0.028% S, 0.12% Mn, with traces of Ni, Cr, Cu and Co) commercial silicon (97% grade) and commercial aluminum (99%). In the early melts, permeabilities as low as 1000 were obtained, even with vacuum melting. Impurities in the silicon (particularly Ca, present to the extent of 0.33%) were at first suspected, but it was later found that, owing to fine gas porosity, the permeability figures obtained for the test rings were fictitiously low. A useful result of this work was to show that calcium, at least in amounts up to approximately 0.3% in the silicon, could be tolerated. The effect of other impurities has not been investigated for the reason that, from the inception of melting under hydrogen followed by degassing with argon, no difficulty has been encountered in obtaining permeability figures of 10,000 and over.

The fact that it was necessary to resort to a method of melting other than in air for the small laboratory melts (which in no case exceeded 10 lb.) does not necessarily mean that air melting will not be satisfactory under production conditions; this will depend to a very large extent on the size of melts and the rate at which melting can be carried out.

Crushing and Ball Milling — Japanese practice is to break castings into 2-in. lumps and anneal for 3 hr. at 1000° C.; the lumps are then crushed in a stamp battery followed by ball milling. The powder is finally separated into two grades — *(a)* 200 to 300-mesh for permeabilities of 80 to 90 and *(b)* less than 300-mesh for lower permeability cores, such as those used for carrier and radio frequency applications.

The only difficulty encountered in this stage of the process was excessive contamination of the powder when using porcelain balls. With flint balls, there was still some contamination from the walls of the mill; the particles from this source, however, were very fine and were almost completely removed in the subsequent decantation to remove excess water prior to drying of the powder.

The screen mesh analysis of powder ball milled for 18 hr. averaged 1 to 10% retained on 200-mesh, 60 to 70% between 200 and 300-mesh, and 25 to 35% through 300-mesh. The Japanese practice of using the 200 to 300-mesh for cores with a permeability of 80 to 90 has been used for most cores made to date, but from recent work it would seem that incorporation of all powder finer than 200-mesh would be permissible.

Annealing Prior to Pressing — As a result of ball-milling, the powder is heavily cold worked, in which condition the permeability is low. One function of annealing at this stage is to restore the permeability; another is to produce an oxide film on the particles for the purpose of insulating each particle from its neighbors, thereby reducing the eddy current losses.

If our information is correct, Japanese practice is to carry out the annealing in two stages: *(a)* 2 hr. at 900° C. in vacuo to restore the permeability, *(b)* followed by 30 min. at 600° C. with a small amount of air admitted to provide the oxide film.

The results of tests on trial cores made from powder annealed as above were most disappointing, particularly in regard to eddy current losses, which immediately threw suspicion on the insulation between the particles. In the hope that deficiencies in the oxide film could be compensated by other means, a batch of rings was made using one per cent of an inert filler (bentonite) in addition to the normal amount of sodium silicate – boric acid binder. The bentonite gave some improvement in interparticle insulation, but only at the expense of permeability, which was in any case much lower than was desired.

At this stage of the work, virtually no experi-

ence had been obtained to guide us in selection of optimum conditions in the later stages of bonding, pressing and baking. With a view to eliminating as many of these variables as possible, small cylindrical compacts were prepared without any binder or filler; resistance measurements were made to evaluate the insulating properties of the films without the added complication of binding or filling materials.

Although the results of these tests were not very consistent they were sufficiently informative to show that no satisfactory insulating films could be produced on any powder that had been heated to 900° C., irrespective of the degree of vacuum (down to 0.1 mm. of mercury), or of the rate of cooling; indeed, the mere heating to 900° C. seemed to destroy any prospect of producing a satisfactory film by any subsequent heat treatment. Pending investigation, it is thought that oxide films produced at 900° C. are either too thick and too easily damaged in the subsequent pressing for the present purpose, or that loss of aluminum at this temperature is sufficient to impair the film-forming properties in any subsequent heat treatment.

The annealing conditions necessary to give good insulation together with minimum film thickness have not been explored fully. The best films obtained to date have been produced by a single anneal of 2 hr. at 600° C. in vacuum (0.1 mm. mercury), but it may well be that improved results could be obtained at some higher or lower temperature.

Inorganic Binder — The following amounts of sodium silicate and boric acid are understood to be used in Japan as binding agents for cores with permeabilities ranging from 20 to 80.

Initial Permeability	% Sodium Silicate	% Boric Acid
80	0.6	0.2
50	1.5	0.5
20 to 30	4.0	1.3

As the number of variables being explored is already very large, it is proposed to leave any investigational work on binding that may be necessary until optimum conditions for the other variables have been found. In the meantime, the quantities of binder constituents appropriate to cores with permeability 80 are being used for all experimental cores.

Pressing — The rings we have been using have a 50.5-mm. external, 30-mm. internal diameter, and a 10-mm. thickness for two rings — these being chosen to correspond with the particular type of commercial Permalloy core being used as the standard of performance. Because of the limited capacity of our press, it has been necessary, until very recently, to limit pressing to 224,000 psi.; only a few rings have been pressed at 257,000 psi. It is understood that Japanese procedure after addition of the binder is to partially dry the powder until it is sticky and to press as follows:

Initial Permeability	Compacting Pressure, Psi.
80	257-291,000
50	190,000
20 to 30	101,000

Sendust powder is both hard and angular, characteristics which result in poor flow and poor packing. The incidence of cracking was rather high initially, but was reduced considerably by careful leveling of the charged powder and the provision of a taper (0.04 in. per in.) at the exit end of the die. Thorough drying of the powder and slow pressing of the compacts out of the die are other measures that have helped to reduce cracking.

Baking — The final operation of baking serves the dual purpose of hardening the binder and of producing a marked improvement in magnetic properties (higher permeability and lower hysteresis losses consequent on relief of stresses resulting from pressing). Obviously, there will be an optimum baking temperature below which recovery of the magnetic properties will not be as complete and above which some disruption of the bond is to be expected, with an increase in spacing between the particles, and consequent reduction in permeability.

The information obtained from Japan was that baking was carried out by heating in air

Table III — Effect of Particle Size Distribution*

Core Sample	Particle Size Distribution, %			μ *(a)*	h *(b)*	e_c *(c)*
	150 to 200-Mesh	200 to 300-Mesh	300-Mesh			
58	100	—	—	70	60	1.6
54	—	100	—	76	45	1.0
55	—	100	—	77	70	1.2
56	—	100	—	75	85	1.3
60	—	50	50	74	65	0.9
61 *(d)*	—	83	17	79	55	1.1
59 *(e)*	6.7	65.0	28.3	78	50	1.2
57	—	—	100	72	55	0.8

*Initial permeability 12,000; compacting pressure 224,000 psi.; baking treatment 1 hr. at 700° C., cool at 60° C. per hr. to 600° C., air cool below 600° C. *(a)* Permeability. *(b)* Hysteresis loss coefficient of core. *(c)* Eddy current loss coefficient of core. *(d)* Proportions calculated to give closest packing. *(e)* Powder as obtained from ball mill without sieving.

Table IV — Effect of Baking Treatment*

Core Sample	Baking		Cooling		μ *(a)*	h *(b)*	e_v *(c)*
	Temp., °C.	Hours	to 600° C.	Below 600°			
75	600	1	Air	Air	89	56	0.79
71 *(d)*	700	1	Air	Air	91	71	1.0
73	700	4	Air	Air	83	42	0.89
72 *(d)*	700	1	60° C./hr.	Air	85	63	0.93
74	700	4	60° C./hr.	Air	84	43	0.82
76	800	1	Air	Air	78	41	1.04
77	800	1	60° C./hr.	Air	75	43	1.10
78	900	1	Air	Air	69	45	1.45
79	900	1	60° C./hr.	Air	66	59	1.94

*Initial permeability 30,000; particle size — all particles finer than 200-mesh; compacting pressure 257,000 psi. *(a)* Permeability. *(b)* Hysteresis loss coefficient of core. *(c)* Eddy current loss coefficient of core. *(d)* Two cores processed identically with No. 71 and 72, but made from alloy with permeability 12,000, gave slightly lower hysteresis loss coefficients (44 and 49) and slightly higher eddy current losses (1.16 for each); permeability was 87.

for 30 min. at 580 to 630° C. It was also stated that the baking operation was a critical part of the process and that the remaining details would not be disclosed.

Our own work would tentatively confirm the suitability of baking at approximately 600° C., but a more detailed survey in the range 500 to 700° C. has yet to be made. As will be seen from the statement of the present position, which follows, the magnetic properties (with the exception of hysteresis losses) deteriorate progressively as the baking temperature is increased from 600 to 900° C. Rate of cooling seems to be unimportant (effects of air and slow cooling shown in Fig. 3), at least within the temperature range we investigated.

PRESENT POSITION

The present position of the investigation can be judged from the results listed in Tables III and IV which give, respectively, the effect of particle size distribution and baking treatment. The following factors were common to most of the cores reported on in the forementioned tables:

Raw Materials: Ingot iron, commercial silicon (purified), commercial aluminum.

Melting: Under hydrogen, degassed with argon.

Annealing of Powder: 2 hr. at 600° C. in vacuo (0.1 mm. of mercury).

Binder: Sodium silicate 0.6%, boric acid 0.2%.

The effect of baking treatment (Table IV) on the magnetic properties of the cores is much more readily appreciated from the curves shown in Fig. 3. In assessing the capabilities of the material, results given for baking temperatures over 700° C. obviously should be disregarded as being too far removed from optimum.

While these results should be regarded only as a very useful starting point for a more detailed investigation, there can be little doubt that cores made under suitable conditions, as they are known at present, would form an acceptable substitute for Permalloy cores of 80 to 90 permeability should the nickel position render such a substitution necessary. As seen at present, the main difficulties that may occur in production would pertain to pressing of the cores.

Acknowledgment — This paper, which is based on work done by N. J. Kelly and K. Bailey, Defense Research Laboratories, is published by permission of Chief Scientist, Department of Supply, Australia. Testing of the cores was done by Research Laboratories of the Postmaster-General's Department, to whom due acknowledgment is made.

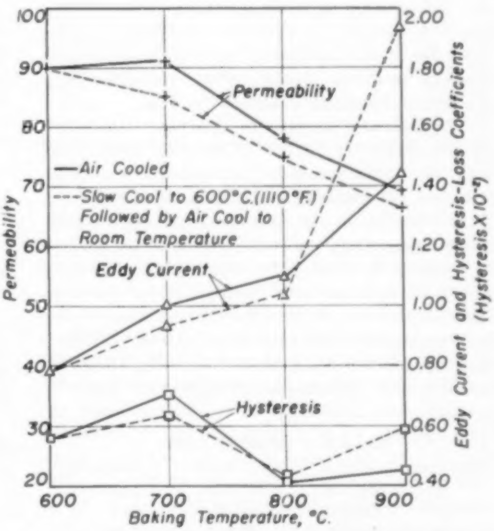

Fig. 3 — Effect of Baking Treatment on Magnetic Properties of Cores Pressed at 257,000 Psi.

Continuous Heat Treatment of Aluminum Alloy Strip

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Continuous heat treatment of aluminum alloy strip has occupied the attention of engineers for a number of years. Although more or less satisfactory solutions have been proposed and adopted, the problem of quenching strips of duralumin 24S, 24S Alclad, and 17S remains rather acute since the development of tandem rolling mills for rolling long coils of wide strip.

In 1939 the Central Society for Light Alloys decided to install at Issoire, France, a modern plant which would include tandem mills for hot and cold rolling of wide aluminum alloy strip. It was therefore essential for us to perfect a continuous method of heat treating the product. Although several tests had been made on various methods for solution heat treatment in the various plants of our group, the *time* necessary to dissolve the microconstituents continued to create a major problem in the design of continuous equipment for large-scale production.

Preliminary Tests — In order to determine the necessary conditions to be met, systematic tests were undertaken in the laboratories. The principal results of these tests are as follows:

To determine the minimum time of heating before hardening, 0.040-in. sheets were heated in a salt bath for various times up to 16 min., then quenched in water and tested in tension. The composition of the sheet tested was of the duralumin type: 0.45 to 0.49% Fe, 0.69 to 0.70% Si, 4.07 to 4.11% Cu, 0.81 to 0.82% Mg and 0.65 to 0.67% Mn. Results are tabulated in Table I.

Table I — Effect of Time

Minutes	Yield	Ultimate	Elongation
1	31,100	61,600	24.0%
2	34,850	59,000	23.2
4	34,150	60,700	24.0
8	35,300	61,600	24.1
16	35,600	61,700	23.8

Next, the effect of cold work (its amount) was studied by rolling a 0.32-in. plate down to 0.158, 0.079 and 0.035 in. respectively. As a consequence, cold reductions of 105, 310, and 810% were secured. Some of the sheets were homogenized at 925° F. (495° C.) for 10 hr., followed by air cooling, while others were not homogenized. These sheets were then heated in a salt bath for various times, from 15 sec. to 20 min., then quenched in water. After four days of natural aging, the mechanical properties listed in Table II were obtained.

From these data one finds:

1. That the homogenization treatment was sensitive to certain factors which influence the rate of solution.

2. That a desired minimum value of the tensile strength, namely, 57,000 psi., was obtained after 3 min. of heating for 4-mm. (0.158-in.) sheet — that is, a 105% reduction; after 2 min. of heating for 2-mm. (0.079-in.) sheet — that is, a 310% reduction; or after 1 min. of heating for 0.9-mm. (0.035-in.) sheet — that is, an 810% reduction.

3. The optimum properties secured after four days of natural aging were 8 min. of heating for 0.158-in. sheet (reduced 105%), 5 min. of heating for 0.079-in. sheet (reduced 310%), and 3 min. of heating for 0.035-in. sheet (reduced 810%).

These differences in heating times were not commensurate with the difference in thickness. In fact, the coefficient of heat transmission between the salt bath and duralumin sheet is 0.011, and the heating time T in seconds necessary to bring a sheet of thickness t in millimeters up to temperature is

$$T = 12.4\,t$$

which works out to be 12 sec., for 0.9-mm. (0.035-in.) sheet and 50 sec. for 4-mm. (0.158-in.) sheet.

It was thought, therefore, that the observed difference was due to the varying amounts of cold reduction.

The influence of cold reduction before hard-

*Translated by Paul S. Methé, research engineer, Aluminum Research Laboratories, New Kensington, Pa.

ening was then studied on duralumin sheets, 1 mm. thick (0.040 in.), having been reduced cold 0%, 100%, and 700%, respectively, and also 3.8 mm. (0.150 in.) thick having been reduced cold 0% and 100%.

Properties listed in Table III (p. 90) were obtained after various times of heating in the salt bath, followed by a water quench and a natural aging period of seven days.

From these mechanical tests, one can easily see the influence of cold rolling on the rate of solution of constituents:

1. For 1.0-mm. (0.040-in.) sheets cold rolled 700%, a tensile strength of 58,400 psi. was secured after 1 min. heating; whereas 3 min. was required to develop that strength in sheets not cold rolled.

2. Optimum values of tensile strength, tensile yield strength, and elongation were obtained for 1.0-mm. sheets cold rolled 700% after 2 to 3 min. of heating, whereas sheets not cold rolled required 5 min.

In order for the 3.8-mm. (0.158-in.) sheet to have the necessary mechanical properties, the following times were established: 5 min. at temperature if not cold rolled, and 2 to 3 min. for sheets having 100% cold reduction.

Similar tests were made on 1.0-mm. duralumin sheet that had been cold rolled intermediate amounts between the 100 and 700% shown in Table III, and from them it was concluded that optimum properties could be acquired after 1 min. of heating at 925° F. (495° C.) if the sheet had previously been cold rolled 400% or more. For lighter reductions, 2 min. at heat was required.

Similar results were noted in a series of tests performed on 24S strips, 0.040 in. thick, 40 in. wide, in the laboratory of the United Engineering and Foundry Co.'s plant at New Castle, Pa., with heating times in salt bath ranging from 15 sec. to 20 min. Satisfactory mechanical properties were obtained with at least 30 sec. at heat, fast quenching, and five days of natural aging.

Table II — Effect of Cold Reduction on Homogenization

Time (Minutes)	Reduced 105%			Reduced 310%			Reduced 810%		
	Yield	Ultimate	Elong.	Yield	Ultimate	Elong.	Yield	Ultimate	Elong.
			Aluminum Alloy Sheet Not Homogenized						
¼	10,100	31,850	14.2	23,750	45,250	21.1	29,300	50,750	20.4
½	19,340	44,400	18.5	27,300	50,500	22.0	33,000	54,100	19.6
1	21,200	47,250	18.4	30,150	54,100	20.7	32,900	57,600	22.2
2	26,750	54,500	19.4	33,800	59,000	23.1	36,900	60,800	22.1
3	25,500	57,900	21.4	35,200	61,600	22.4	40,000	63,600	22.0
5	30,700	60,100	22.3	37,000	63,000	25.0	38,700	63,400	23.2
8	32,150	62,550	23.1	37,700	64,000	24.8	39,250	65,150	22.1
12	33,400	62,900	22.7	38,800	64,800	23.5	39,000	65,500	23.7
20	34,000	62,900	24.6	40,000	65,550	24.7	39,800	66,100	23.7
			Homogenized Aluminum Alloy Sheet						
¼				18,500	42,600	20.7	26,750	50,600	21.4
½				24,300	50,600	21.5	29,900	55,900	31.3
1				29,900	55,000	19.5	34,100	59,500	21.8
2				33,900	60,200	22.4	38,200	62,800	22.1
3				35,300	61,900	25.0	37,700	63,600	24.1
5				37,800	64,100	23.9	37,800	63,900	24.5
8				37,700	64,000	22.6	39,000	65,450	22.7
12				38,700	64,500	24.2	38,600	65,250	23.2
20				39,100	65,100	24.4	39,100	65,500	26.1

MINIMUM RATE OF QUENCH

To get some information on the minimum quenching speed that would be necessary some tests were conducted on 1.0-mm. (0.040-in.) duralumin strips, 500 mm. (19.7 in.) wide, heated to 500°C (930° F.) and held at temperature for 20 min. To quench, the strip was passed through a turbulent water spray. These tests have shown *(a)* that the sheets were deformed very little by quenching in the water spray and *(b)* that the minimum rate of passage through the water spray should be 1.5 meters per min. (approximately 5 ft. per min.). The properties obtained by such a heat treatment were then comparable to those given to the metal by a rapid quench in cold water.

COMMERCIAL HEAT TREATING SCHEDULE

The conclusions from these different tests show that the continuous quenching of aluminum alloy strip of the duralumin type was possible under the following conditions:

Approximate time at temperature: 2 min. for 1.0-mm. (0.040-in.) sheet; 4 min. for 4.0-mm. (0.158-in.) sheet.

Minimum rate of passage through the quench: 1.50 m. per min. (approximately 5 ft. per min.).

One can therefore see that it is theoretically possible to set up a continuous schedule using a conventional furnace that only permits the heating of wide but relatively short strip, but because the strip must travel at a relatively high speed for the process to be economically feasible, rapid heating to the desired temperature would be difficult to insure.

During the last war, we were greatly hampered in conducting our tests because of the working conditions in France and the difficulty of procuring the necessary materials. However, we undertook different experiments on the heating of strip by electric currents. Also, we entered into an agreement with La Compaigne De Telegraphie Sans Fil, Paris, to study high-frequency induction heating. Still, nothing was accomplished on this project prior to the liberation of France at the close of 1944.

In February 1945, when normal trade relationships between the United States and France were again possible, our Society started discussions with the United Engineering & Foundry Co. in Pittsburgh concerning new rolling mills for the plant at Issoire. (In 1939, the Society had ordered similar equipment but, as a consequence of the war, the mills were not delivered. Subsequently, Reynolds Metals Co. acquired these mills and installed them at Lister Hill, Ala.)

Our friends of the United Engineering & Foundry Co. indicated that they also regarded continuous heat treating as a necessary complement to the rolling mill. M. D. Stone, manager of their development department, had previously studied the induction heating of steel for the continuous tin plating process, and already had envisioned its application to aluminum. With this confirmation of common ideas, M. Bresson of the Central Society for Light Alloys investigated details of the process in complete cooperation with the U. S. firm. The latter, in addition to the ideas of Dr. Stone, had the necessary mechanical experience to design the necessary auxiliary equipment.

A test furnace was constructed in the American plant at New Castle, Pa., where the first tests had taken place. The general outline of the furnace installation is described as follows:

Table III — Effect of Cold Reduction Before Hardening

Time (Minutes)	No Reduction			100% Reduction			700% Reduction		
	Yield	Ultimate	Elong.	Yield	Ultimate	Elong.	Yield	Ultimate	Elong.
	Duralumin Sheets 1.0 Mm. (0.040 In.) Thick								
1	26,000	50,500	20.0	29,850	55,500	20.0	35,600	58,400	20.0
2	32,700	57,000	17.0	32,700	57,600	19.0	37,000	59,700	22.0
3	32,700	58,300	19.5	32,700	60,500	19.0	38,400	62,500	20.0
4	35,600	57,600	15.5	35,600	60,500	19.0	38,400	62,500	22.0
5	37,000	61,200	19.0	35,600	61,100	20.0	38,400	61,100	20.0
6	34,200	61,200	19.0	34,200	61,100	19.0	38,400	61,100	19.0
	Duralumin Sheets 3.8 Mm. (0.150 In.) Thick								
1	24,200	48,400	20.0	27,500	54,000	20.0			
2	27,000	57,000	18.0	31,300	57,600	22.0			
3	32,700	58,400	19.0	35,600	61,900	23.0			
4	34,100	59,700	20.0	35,600	61,100	22.0			
5	32,700	59,700	19.0	34,100	61,100	21.0			
6	34,100	61,100	19.0	35,600	62,600	22.0			
7	35,600	61,100	19.0	35,600	61,100	22.0			
8	35,600	61,100	22.0	35,600	62,600	22.0			

CONTINUOUS HEAT TREATING FURNACE

The continuous furnace is large enough for aluminum strip up to 56 in. wide and 0.010 to 0.080 in. thick. Speed is a function of the thickness, and varies from 0 to 50 ft. per min. (15 m. per min.).

Solution heat treatment is assured by an induction coil of 1875 kva. power, single phase, 60 cycles, 440 volts, which quickly preheats the strip to approximately the solution heat treating temperature. This requires less than a minute. Next the strip passes into a stabilizing furnace in which the proper temperature is maintained. This stabilizing furnace is electrically heated and the atmosphere is continuously circulated in order to bring the strip up to the exact solution heat treating temperature in a uniform manner, and to achieve this temperature as quickly as possible. Upon leaving the furnace, the strip is quenched by water sprays.

The various components of the complete unit are shown in Fig. 1. The quenching bath is located immediately below the furnace, and consists of a series of water sprays. Furnace tightness (and premature air cooling before quenching) is insured by immersing the exit door below the water level.

A warm air dryer immediately follows the water bath. Located above and below the moving strip are longitudinal tubes through which hot air is blown. This system proved to be quite efficient; it requires a 20-hp. motor to drive the blower.

Aside from usual motors and their automatic control the electrical equipment includes devices for regulating the current going into the induction heating coils. Incoming power is supplied at 440 volts, 60 cycles, to an auto-transformer and a voltage regulator.

The induction coil heats the strip with a transverse flux of 1875 kva., 490 volts, 60 cycles. A battery of condensers of 1950 kva., 575 volts, 60 cycles, single phase, paralleling the induction core, correct for power factor. The induction coil is water cooled. The gap between poles, for the passage of strip, is 3 in., with a possible regulation of ± 0.5 in. On each half of the coil are fixed edge protectors to avoid overheating the edge of the strip, and these protectors are similarly cooled.

An arrangement of photo-electric cells adjusts the edge protectors according to the various widths of strip (30 to 56 in.). By other photo-electric cells, the lateral movement of the strip is automatically followed to ± 2 in.

EDGE PROTECTORS

The edge protectors originally had guide rolls at their base which supported the edges of the strip and held it in a central position. These guide rolls have since been discarded because they scratched and would even tear the strip.

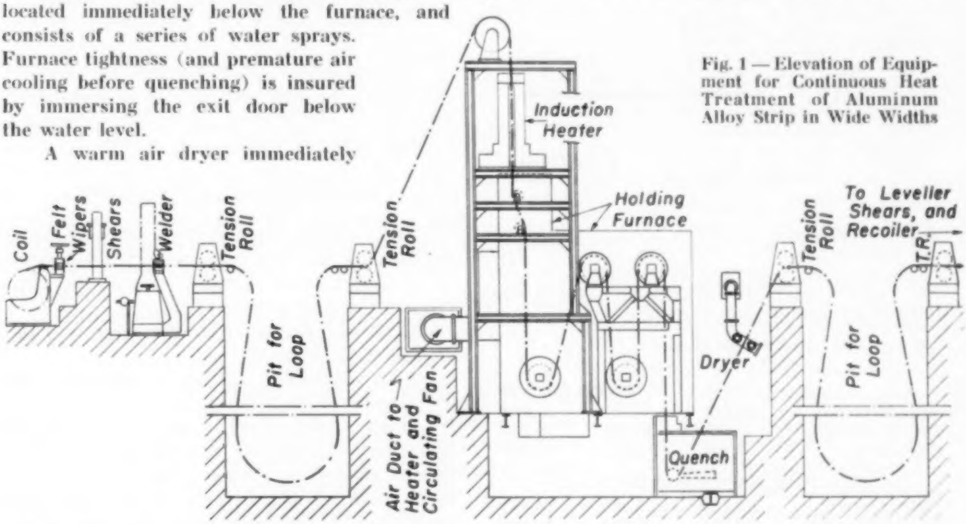

Fig. 1 — Elevation of Equipment for Continuous Heat Treatment of Aluminum Alloy Strip in Wide Widths

A section of the edge protectors as now installed is sketched in Fig. 2. They are made of copper and are water cooled. The interior insulation is a cement mixed with asbestos fiber. The overlapping distance can be varied from 0 to 4 in.

With speed constant at 12 ft. per min. and with various rates of induction heating (variable intensities) it was noted that the temperature from center to side of strip varied considerably with different positions of the edge protectors. In service, temperature will be checked at a point intermediate between sides and center by a thermocouple placed on the end of a long lever. The thermocouple will ride the moving strip intermittently until the reading is made.

Several temperature surveys were made which

gave the results of Fig. 3. If the protectors were not used an important difference in temperature was registered from edge toward center of strip, amounting to as much as 60° C. (110° F.). On the other hand, when the overlap was as much as 4 in., the reverse situation occurred and the edge was as much as 100° C. (180° F.) cooler than the center.

Figure 3 shows, however, that with an overlap of 2 in. this differential no longer exists. When speed was 18 ft. per min., the induction coil regulated for 650° F. (345° C.) center temperature, and the air furnace maintained at 635 to

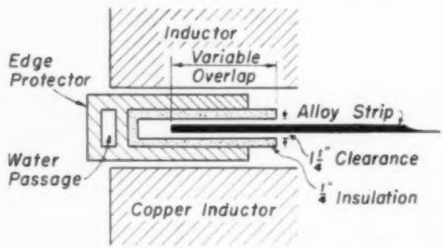

Fig. 2 — Cross Section of Movable Edge Protectors

650° F. (335 to 345° C.) the strip is nearly uniform in properties. For example:

Strip as Rolled

	Edge	8 In. From Edge	Center
Yield strength	38,700	38,500	39,000
Tensile strength	40,000	40,250	40,250
Elongation	3.4%	3.4%	3.4%

After Heat Treatment

	Edge	8 In. From Edge	Center
Yield strength	18,100	15,950	16,800
Tensile strength	33,700	30,750	32,000
Elongation	19.9%	20.7%	21.7%

Other tests indicated that when the inductor coils were spaced to less than 3¼ in. a high power factor was achieved. When 24S strip, 0.040 in. thick and 40 in. wide, is put through the equipment (coils spaced at 3 in. and edge protectors overlapping 2 in.) at 18 ft. per min. the strip is heated to 880° F. (470° C.) with 2800 amp. of current. At 30 ft. per min. about 3000 amp. is required.

Coils of 24S Alclad treated in the furnace were sampled and tested in the heat treated and aged condition. Results are given in Table IV.

The higher speeds of 30 ft. per min. gave unsatisfactory properties, while sheet treated at 19 ft. per min. yielded desirable properties. It is felt, however, that this low speed is not the maximum possible. Tests at New Castle were terminated after the supply of strip was exhausted.

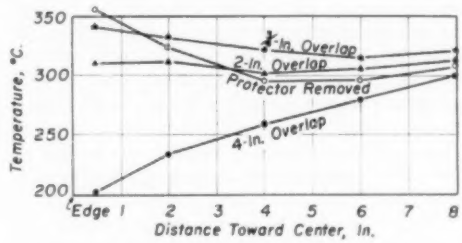

Fig. 3 — Temperature Variation in Strip for Four Positions of Edge Protectors

Nevertheless, these first results were encouraging and the furnace has been shipped to France. At this writing (June 1951) it has not yet been received and put into action.

Conclusions from American Tests

The following important matters were determined from the tests conducted at New Castle:

1. The correct method to pass the strip through the heat treating furnace.
2. Proper regulation of the speed and the voltage of the furnace.
3. A practicable method of measuring the temperature of the moving strip.

Minor modifications in the furnace and its operation will doubtless be made when the furnace is erected in France. We believe it will mark a distinct advancement in the economical production of aluminum alloy strip and coiled strip-sheet.

Table IV — 24S Alclad Strip, Heat Treated in Continuous Furnace and Aged

Position	Yield	Ultimate	Elongation
Speed 19 Ft. per Min.; 2400 Amp.			
Right edge	35,000 to 38,600	57,500 to 60,500	12.9 to 16.0
Center	36,100 to 40,250	58,100 to 60,900	15.4 to 19.2
Left edge	36,700 to 39,700	57,400 to 59,100	14.5 to 18.5
Speed 19 Ft. per Min.; 2450 Amp.			
Right edge	35,600 to 40,800	58,000 to 59,900	15.0 to 19.0
Center	37,300 to 41,500	58,600 to 60,500	15.6 to 18.6
Left edge	38,000 to 40,300	57,000 to 59,300	15.0 to 18.4
Speed 30 Ft. per Min.; 3000 Amp.			
Right edge	31,600 to 36,100	53,000 to 55,000	13.6 to 17.3
Center	32,000 to 36,700	53,000 to 56,600	12.6 to 18.4
Left edge	31,400 to 34,400	51,400 to 54,000	13.7 to 16.7

Iron and Steel Industry in India

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PROSPECTS of the Indian iron and steel industry are very encouraging, as there are great long-term economic possibilities in the country with its huge population and potential market. Compared to a per-capita consumption of 1180 lb. in the United States, 232 lb. in Russia, 65 lb. in Hungary, 470 lb. in Australia, our consumption of 8 lb. per capita shows our glaring industrial backwardness. India emerged from the war with a clearer realization of the possibilities and implications of industrialization, and it may be interesting to note that 1,100,000 tons of steel consumed in prewar 1939 was less than that of 1914 (1,300,000 tons), and very much less than the 1,700,000 tons consumed in 1929. By 1948 production had only grown to 1,250,000 tons of ingots. This shows that our utilization of steel does not increase even with the increase in population.

Historically, the soil is fertile. Archeologists generally place the birth of the iron age in India about 1400 to 1500 B.C. The historical remains indicate a fairly highly developed iron culture in ancient times. Hyderabad and southern Madras are considered by many to have been the centers of production of Wootz steel, famous for centuries, carried to Damascus and Toledo and being the material from which the famous swords of these cities were made. The iron pillar near Delhi is supposed to be wrought during the reign of Samudragupta about 330 A.D. This pillar was probably made from small blooms, smelted in primitive furnaces similar to those used by the *agarias* (indigenous smelters) still practicing their craft over a wide area in the provinces of Bihar and Orissa (see the sketch map, Fig. 1).

Unfortunately, Indian iron smelters never overcame certain definite limitations, and showed little tendency to progress. They got no further than the export of large quantities of Wootz steel, and the fashioning of splendid weapons in Europe rather than at home was due to the fact that western scientific advances left them untouched.

The first attempt in India to establish industry upon western lines was made in 1831 by Josiah Marshall. The work was started at Porto Novo on the coast about 125 miles south of Madras. His small furnace was capable of yielding about 40 tons of charcoal pig iron per week. The blowing engine was driven by bullocks whenever the 4-hp. steam engine could not work. Fifty years after its inception the company was dissolved.

The first iron and steel works in India which ever attained even a moderate measure of success was established near Barakar, northwest of Calcutta, in 1875. The undertaking suffered many reverses at the outset, but in 1889 it passed into the hands of the Bengal Iron & Steel Co. which is now amalgamated with the Indian Iron & Steel Co. Construction of Tata's large steel plant was started in 1907 and the first iron made in 1911.

Present Development—There are four major producers of iron and steel in India; among them the Tata Iron & Steel Co. is the biggest producer, making in 1939 60% of the pig iron and more than 90% of the steel. The present capacity for finished steel in India is 1,200,000 tons, the main producers and their equipment being listed below. In addition there are a number of small producers, Government Ordnance Factories, and re-rolling mills, but their production is very small compared to the major producers.

Tata Iron & Steel Co., Ltd., at Jamshedpur: Coke ovens; four blast furnaces from 650 to 1100 tons daily capacity (annual capacity 1,300,000 tons of basic and foundry iron, plus 75,000 tons ferromanganese); eight openhearths of 60 to 125 tons, and two 5½-ton electrics in No. 1 shop (annual capacity 375,000 tons of steel ingots); three 25-ton acid converters and three 250-ton tilting basic openhearths in No. 2 shop (annual capacity 700,000 tons of steel ingots); one 25-ton acid converter and two 50-ton tilting openhearths in No. 3 shop (annual capacity 40,000 tons of acid and 20,000 tons of basic steel). Rolling mills for structurals, rails, sleepers and track accessories, wheels, tires, axles, 97-in. plate, merchant shapes, wire and wire products, tool-steel and alloy steel.

Steel Corp. of Bengal, Ltd., at Hirapur, in connection with Indian Iron & Steel Co., Ltd., at Hirapur and Kulti: Four blast furnaces making 775,000 tons annually of basic and foundry iron; two 25-ton converters, one 90-ton openhearth, three 225-ton tilting openhearths (annual capac-

ity 250,000 tons of basic steel ingots and castings); rolling mills for structurals, rails and track accessories, sheet, merchant bars, spring steel and toolsteel.

Mysore Iron & Steel Works at Bhadravati. Wood distillation plant; one 80-ton charcoal blast furnace; two 25-ton basic openhearths and one 25-ton electric furnace; rolling mill for small sections; pipe foundry. This plant also produces about 5000 tons of ferrosilicon annually.

Raw Materials — India is endowed by nature with almost all the raw materials required, and thus produces, next to Australia, the cheapest pig iron and steel in the world. A comparison of prices is shown in the following tabulation.

Table I — Price Comparison, as of Mid-1950

Commodity	U. S.*	U. K.*	Australia*	India
Foundry pig iron	$46.50	$33.65	$22.10	$18.70
Structural steel	76.15	56.50	38.90	52.40
Merchant bars	77.30	62.45	38.90	48.60
Plates	78.40	58.05	41.15	57.47
Rails	84.00	60.65	42.20	48.80
Wire rods	86.25	59.10	41.35	87.90
Re-rolling billets	59.35	47.10	35.80	40.00

*Figures from *Fortune* for November 1950.

Raw materials (located approximately within the circle on the map) are also responsible for the location of our industry in the Bengal-Bihar-Orissa region. The ease with which rich raw materials can be mined and assembled is the main reason for the low costs of production, and it would be unsound to establish new steel plants away from these sources, since India unfortunately does not enjoy the economics of extensive internal water transport.

IRON ORE

India possesses perhaps the largest reserves of high-grade iron ore in the world, as well as huge amounts of low-grade ores.

The richest iron ore field in India is situated in Bihar and Orissa. The first discovery was made by the late P. N. Bose in 1904, and the Gorumahisani Iron Mines of the Tata Iron & Steel Co. were opened in 1910. There are quite a few large areas in this field which have not been worked. Most of the developmental work was done around the 1920's.

Other deposits in this area are vanadium bearing titaniferous magnetites.

The only deposit of high-phosphorus ore is in Bengal. It is poor in iron content (35 to 45%). Most of the easily available ore in this locality has been worked out.

Iron ores are widely distributed in Mysore and Sandur. The Mysore Iron & Steel Works gets its ore from the Bababudan hills. Massive hematites and limonites are known to exist but they have not been properly explored because of their distance from the railhead.

The ores in Madras, where the industry started, are mainly magnetic, low in iron (30 to 40%) and very high in silica. They can easily be concentrated to 55% Fe, but we have not sufficient data on such processes on even a pilot plant scale to get an idea about the economics of their recovery and use.

In Hyderabad the richest occurrence is in the Bailadila range in Bastar district. The ores are mainly hematites. The Bastar deposits are inaccessible at present and far away from any coal fields, but are of high grade, containing 58 to 66% Fe.

Since mineral deposits are not worked on modern lines in India, reserves are not estimated carefully as in Western countries. As high-grade ore is plentiful, no reserves of different grades and categories have been blocked out. However, estimated tonnage may be stated as follows:

State	Reserves	Quality
Bihar and Orissa	10,000,000,000	58 to 68%
Mysore and Sandur	330,000,000	33 to 68
Bastar	2,500,000,000	58 to 66

Obviously these figures are rather astronomical when measured in terms of India's present mining activities. They would doubtless supply the present American industry for a century.

Flux — Although flux is a very important blast furnace raw material, the required quality is not easily available near our steel centers. Furthermore, much must be used; despite a high-grade ore, our coke averages 22.7% ash.

For blast furnace use the maximum limit for silica and alumina in limestone is 5%, whereas in the openhearth it is 4%. Though there are several limestone deposits near the iron and coal fields, few come up to the quality required. Major producers draw their flux from Gangpur district in Orissa, located from 120 to 200 miles from the major producers. Like the steel industry in the United States, ours is not blessed with a near supply of flux.

Perhaps the only mineral required in which we are deficient is fluorspar. Some is known but its quantity and quality is not high enough to work economically.

Map of the Union of India Locating Key Raw Materials and the Four Iron and Steel Plants

BLAST FURNACE PRACTICE

P. E. Cavanagh's articles in *Metal Progress* for April and May, 1950, demonstrate that the location of major iron and steel units is determined more by the availability of high-grade coking coal than good iron ore. More important is the size of the market and the area which can be reached at a competitive price. We agree that, for purely economic reasons, blast furnaces also may be located close to the source of fuel and to the market, rather than to the ore.

As far as furnace practice is concerned, one of the trends is to increase the volume of air blown into the furnace per minute per unit of area. Present Indian practice is to work at the maximum allowable pressure. A great deal of work has been done to determine whether it

is practical to select ore in a certain size range for uniform rate of reduction. This simple change will save coke and increase production, and corresponds with modern trends in blast furnace technique to increase the rate and uniformity of contact between the reducing gas and ore.

NOTES ON FINANCES AND LABOR

The total invested capital in the Indian iron and steel industry, including re-rollers and smelting units at the Government ordnance factories, is about 300 million rupees. Valuation at the present day totals from 1200 to 1500 million rupees ($250,000,000 to $300,000,000).

The industry employs over 72,000 persons, and the average wage paid is the highest of any industry in the country.

Some idea as to the apportionment of income can be had from the following figures from the British Iron & Steel Federation and corresponding ones from the 1949 annual report of Tata Iron & Steel Co., Ltd.

Apportionment of Income in Great Britain

Raw materials, fuel and services	60%
Wages, salaries, national insurance, holidays and pensions	26
General expenses, including rents and insurance	2
Delivery charges	4
Retained in business for depreciation	3
Taxation	4
Dividends	1
Total	100%

Apportionment of Income in India

Raw materials and services	32.47%
Wages, salaries and administration	38.41
Freight	14.39
Retained in business for reserves	2.14
Taxation	7.75
Dividends	4.84
Total	100.00%

Economic conditions in India have changed rapidly during the last decade. The myth of cheap Indian labor is gone. Before World War II, top management of our heavy industries took the general attitude the mechanization had to be done slowly; otherwise it would throw out of employment many hundreds of unskilled workers. In those days the cost of cheap labor did not compare unfavorably with the machines. But, unforeseen factors have altered the situation. The great increase in wages, limitation of hours of work, and the decreased productivity of workers have brought about a situation where now an immediate mechanization is thought to be the best solution of the economic problem in steel and iron.

These statements can be illustrated by the cost sheets of one of the major steel manufacturers. The average labor cost per ton of finished steel in 1939 was Rs.31.54 which in 1948 was Rs.92.8 (up three times) whereas the average output per worker went down from 24.36 tons to 16.30 tons (down one third). This means that the cost of production of a ton of steel increased 194% in one decade. This is a very sorry state of affairs, even without considering that the buying power of the rupee has also gone down considerably during the same time.

COAL

In comparison with our reserves of iron ore, our metallurgical coal reserves are low. Restricting the estimates to 4-ft. seams and taking the maximum workable depth as 1000 ft., our reserves of all grades of coal have been computed to be 20,000,000,000 tons. Even the estimated 700,000,000 of coking coal contain high ash; if washed, the amount will shrink to 500,000,000.

Even after washing, the ash content may be 15%. If the ash is reduced further, the recovery is very low. Considering the advantages of a low slag fall in the blast furnace, it may be economic to gasify part of the coal and introduce it through supplementary tuyeres. This appears to be a radical method of "cleaning" high-ash coals, but it is not altogether visionary since prewar German researches indicate that only 35% of the blast furnace's fuel is utilized for metallurgical reactions, whereas the remainder preheats the burden. If fuel is charged partly in the gaseous and partly in the solid form, it will obviously require some modification in the present designs of the furnaces.

The coal industry in India produces some 30,000,000 tons of coal per annum, which is enough for internal use and some moderate exports to the neighboring countries. At this rate our reserves are enough to last 700 years.

MANGANESE

India is the second largest producer of manganese in the world in tonnage; on a quality basis her manganese is best. Though production varies from 300,000 to 1,000,000 tons per year, the internal consumption does not exceed 80,000 tons. The rest is exported.

Manganese is widely distributed, but from the standpoint of the *(Continued on p. 218)*

INTRICATE
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DUCTILE IRON

DUCTILE IRON is a cast ferrous product that combines the *process advantages* of cast iron with many of the *product advantages* of cast steel.

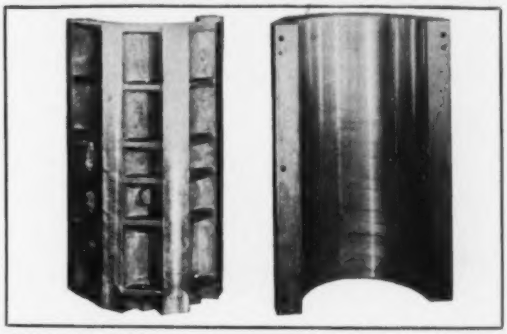
In less than two years, ductile iron has attained wide acceptance because it offers excellent castability, high mechanical properties, and good machinability. Parts cast in ductile iron show superior pressure tightness, high modulus and resistance to shock.

Typical current applications include chemical pots, compressor shells, cylinders for hydraulic presses, fly wheels, housing for electric power driven tools, large gears for coal mine equipment, vise jaws, and many other parts.

AVAILABILITY

Send us details of your prospective uses, so that we may suggest a source of supply from some 100 authorized foundries now producing ductile iron under patent licenses. Request a list of available publications on ductile iron . . mail the coupon now.

STAVER FOUNDRY COMPANY, Virginia, Minn., produced this large hoist drum in ductile iron to meet requirements of toughness with strength, and wear resistance with good machinability.



PYOTT FOUNDRY & MACHINE CO., Chicago 7, Ill., produced these ductile iron castings for dies for forming 24" to 36" diameter pipe from steel plate of 1/4" to 1/2" thicknesses. The finished tooling was done by the Vernon Allsteel Press Co. of Chicago. The dies are to be used in large presses that exert 18,000 tons pressure.

ST. PAUL FOUNDRY & MANUFACTURING CO., St. Paul 3, Minn., cast this hydraulic head for a billet conditioner in ductile iron having 92,000 p.s.i. tensile strength, 67,000 p.s.i. yield point and 7.8% elongation.

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Improved Aluminum Bearings (Al-Sn and Al-Sn-Cu Alloys)

ALUMINUM-TIN ALLOYS offer a promising field for the development of new bearing materials. According to Hunsicker and Kempf[1] the scuffing load on a certain bearing lined with pure aluminum is as low as 50 lb., whereas this increases continuously with the addition of tin to the alloy, reaching about 450 lb. at 25% tin. Commercial aluminum bearings normally contain 6 to 7% of tin together with minor constituents such as copper, nickel, and silicon, and are generally used in the cast and stabilized condition. They possess a low coefficient of friction at high bearing loads and a good resistance to seizing.

In previous work it developed that properties at room temperature and at the moderately elevated temperatures (reached by the bearings during operation) are pronouncedly affected by the microstructure. For example, fatigue limit at 70° F. is reduced by quantities of tin sufficiently great to form a continuous phase through the matrix. Furthermore, reduced ductility at elevated temperature is associated with a particular tin distribution — continuous interdendritic and intergranular films.[1] (References will be found on p. 224.)

Improved mechanical properties both at room and elevated temperatures are associated with discrete particles of tin in a continuous aluminum matrix. This can be achieved by control of casting conditions, or more readily by cold working followed by recrystallization. Alloys containing 30% tin or more with excellent mechanical properties can be produced by the latter method and may combine the softness of babbitt with many times its fatigue resistance at operating temperatures (around 300° F.) and their major constituent is aluminum. As to strategic alloys, the present supply of both constituents is good.

Our experiments were made on laboratory melts cast into DTD standard $\frac{15}{16}$-in. round test bars, 6 in. long. Molds were either baked sand, aluminum bronze, or "water chill cast" (by pouring into a 1¼-in. cylindrical thin sheet steel container and allowing water to rise in an outer container at such a rate that directional solidification occurred from the bottom of the ingot). These various molds enabled us to study the influence of rate of solidification on microstructure.

Tin Distribution — The following account has been extracted directly from Hunsicker's paper:[3]

"The size, shape and distribution of the tin constituent in binary aluminum-tin alloy castings vary primarily with the tin concentration and the solidification rate, although minor microstructural changes may be effected by heating the alloys to temperatures above the eutectic temperature. With increasing concentrations of tin it tends to form interdendritic and intergranular networks of increasing continuity. This tendency, within certain concentration ranges, can be counteracted by increasing the rates of solidification, as well as by the addition of certain other alloying elements (notably silicon). At tin concentrations in excess of about 20%, the tin is the continuous constituent, even with the most rapid practical rates of solidification."

In our work, a very large number of photomicrographs were made. Rather than reproduce them all, which would consume inordinate space, a code was adopted to represent distribution of tin particles, and the structures are described in a series of tables. (A few representative micros will also be shown.) The code used in these tables is given overleaf. In the

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Table I — Distribution of Tin Particles in Binary Al-Sn Alloys With Different Rates of Solidification

Casting Method	Tin Content, %							
	5	7.5	10	12.5	15	20	25	30
Sand	F	—	F	—	F	F	—	F
Chill	DF/G†	—	DF/G	—	F*	F	—	F
Water chill	F/e	F/e	F/e	F/e	F/e‡	F/e	F/e	F/e

*Fig. 1. †Fig. 2. ‡Fig. 3.

Code Used in Tables

- F Continuous interdendritic films
- DF Discontinuous interdendritic films
- G Discrete globules
- P Discrete particles other than globules
- e Fine eutectic with discontinuous films
- c Structure is large and coarse
- — Alloy not made
- () Parentheses represent small amount of phase
- → Structure in process of change

event the structure is mixed, containing more than one of the above, two symbols are separated by an inclined line.

Binary aluminum-tin alloys are described in Table I. All sand cast bars and chill cast bars with 15% tin or more showed continuous interdendritic films of tin (see Fig. 1). All alloys cast in water chills had continuous interdendritic films, plus regions (varying in proportion) which were much finer in scale and probably corresponded to eutectic colonies, as shown in Fig. 3.

Effect of copper was studied by adding it progressively to an 85% Al, 15% Sn base. Microstructures are summarized in Table II. Discontinuous films appeared in sand cast bars with 3.0% and more copper, and in chill cast bars with 1.0% and more copper. The alloys cast in water chills showed continuous films but the continuity of the fine eutectic structure was broken with more than 1.5% of copper, as typified in Fig. 4.

Similarly, effect of variable tin was studied in a base alloy of 97% Al, 3% Cu (see Table III), and in a base alloy of 98% Al, 2% Cu (see Table IV). Continuous films were absent in all sand cast alloys, in all chill cast except the one with 30% tin. The water chill cast alloys possessed continuous films of tin but the fine eutectic structure was normally discontinuous (Fig. 4).

MELTING CONDITIONS

Varied melting conditions made no observable effect on the resulting structure. This statement applies to bars cast at 1310 to 1380° F. (710 to 750° C.), degassed with chlorine, degassed with flux, or cast without degassing.

The results described above are in substantial agreement with the conclusions given by Hunsicker except that there is a reversal to the film type of distribution in the water chill cast specimens. The rate of solidification applying in this instance may have been greater.

It is evident from these tests that a discontinuous distribution of tin particles can be obtained in binary alloys with up to at least 10% of tin by using a suitable rate of solidification. This range can be extended to 20% tin by the addition of 2 to 3% of copper.

Representative Microstructures, As Cast; 100×; Etched in 2½% Ammonium Persulphate Solution Which Blackens Tin

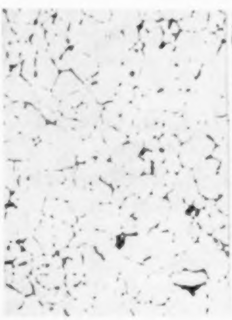

Fig. 1 — Chill Cast; 85% Al, 15% Sn; Continuous Films. Sand cast grains are very much larger

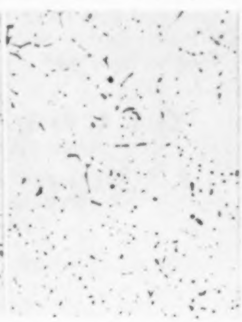

Fig. 2 — Chill Cast; 95% Al, 5% Sn, Discontinuous Films and Globules

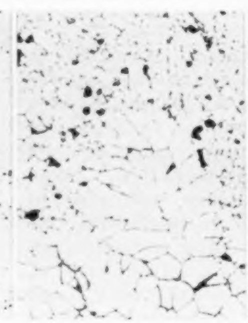

Fig. 3 — Water Chill Cast; 85% Al, 15% Sn; Continuous Films and Eutectic

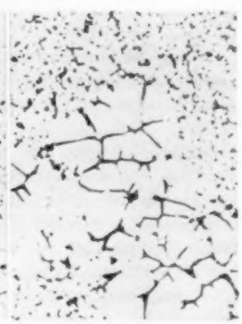

Fig. 4 — Water Chill Cast; 82% Al, 15% Sn, 3% Cu; Continuous Films and Discontinuous Eutectic

Table II — Distribution of Tin Particles in Ternary Al-Cu - 15% Sn Alloys With Different Rates of Solidification

Casting Method	Copper Content, %								
	Nil	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
Sand	F	F	F	F	F	—	DF	—	DF/G
Chill	F*	F	DF/G	G	G	DF/G	G	DF/G	DF/G
Water chill	F/e†	F/e	F/e	F/de	F/de	—	F/de‡	—	DF/de

*Fig. 1. †Fig. 3. ‡Fig. 4.

TIN DISTRIBUTION IN WROUGHT ALLOYS

Notwithstanding the last statement, it is quite possible that a commercially and technically desirable alloy and casting conditions may produce metal with undesirable films of tin in its structure. We therefore inquired into the possibility of breaking up these films by heat treatment, cold work, or a combination of both, choosing the water chill cast specimen of the 70-30 Al-Sn alloy. Its structure is essentially like the one shown in Fig. 3.

As-cast samples, annealed various times from 1/4 to 48 hr. at temperatures from 430 to 930° F. (220 to 500° C.), gave a mixture of globular particles and films. Heat treatment at the higher temperatures produced a coarse structure in a shorter time, but grain boundary films were always present.

Samples stretched 5 to 30% and then annealed at 430° F. (220° C.) changed very little in microstructure, although the fine eutectic may have balled up slightly, as in Fig. 6.

Similarly, stretching 5 or 10% did not have a very pronounced influence on the microstructural changes during the subsequent heat treatment at a higher temperature than 430° F. The transfer from the cast structure to the mixture of globules and films occurred over much the same temperature range, but the microstructures contained films after all heat treatments.

Table III — Distribution of Tin Particles in Ternary Al - 3% Cu-Sn Alloys With Different Rates of Solidification

Casting Method	Tin Content, %						
	5	10	12.5	15	17.5	20	30
Sand	—	DF	—	DF	—	DF	—
Chill	G	DF/G	DF/G	G	DF/G	DF	F
Water chill	—	F/de	—	F/de*	—	F/de	F/de

*Fig. 4.

Table IV — Distribution of Tin Particles in Ternary Al - 2% Cu-Sn Alloys With Different Rates of Solidification

Casting Method	Tin Content, %		
	15	20	30
Sand	DF	DF	F
Chill	G	G	DF/G
Water chill	F/de	F/e	F/e

Stretching 20 and 30% and then annealing was more successful, as shown in Table V.

Cold working 20 and 30% greatly reduced the tendency to retain films on annealing at 660° F. (see Fig. 7 and 8), but there was a tendency to revert to films at the higher annealing temperatures.

It thus appears that discontinuous particles

Representative Microstructures of Cold Worked and Heat Treated 70-30 Al-Sn Alloys; 150×

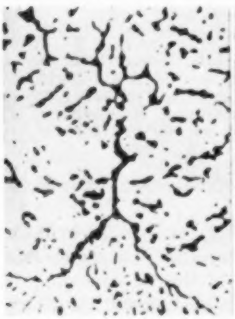

Fig. 5 — Stretched 10%, Annealed 4 Hr. at 570° F.

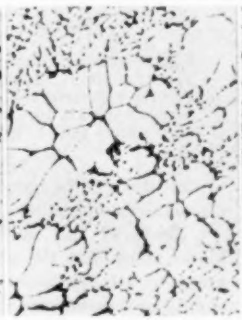

Fig. 6 — Stretched 20%, Annealed 48 Hr. at 430° F.

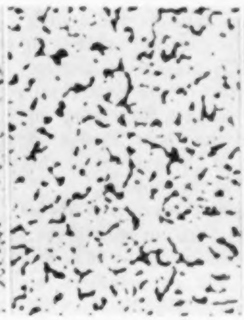

Fig. 7 — Stretched 20%, Annealed 1 Hr. at 660° F.

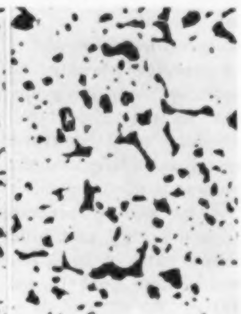

Fig. 8 — Stretched 20%, Annealed 16 Hr. at 660° F.

Table V — Microstructure of 70-30 Al-Sn Alloys After Cold Work and Heat Treatment

Stretch	Heat Treatment, Time and °F.						
	Hours	480°	570°	660°	750°	840°	930°
20%	¼				F → G	G/F	P/G → F
	1	F/c	F → G	G/P(F)*	P/(F)	P/F	P → F
	4	F → G	G/F	G/P/(F)	P/(F)	P → F	P → F
	16	G/F	G/F	cP†			
	48						
30%	¼				P(F)	G	cP → F
	1	F → G	F → G	P	P/G	P	cP/G → F
	4	F → G	P/G	P	cP	cP → F	cP/G → F
	16	G	P/G	cP	P		cP/G → F
	48						

*Fig. 7. †Fig. 8.

are favored by a high degree of cold work and recrystallization at low temperature. Stretching by 20% is probably the minimum degree of cold work, and 660° F. (350° C.) the optimum annealing temperature for such desirable results. Higher temperatures may be used but the degree of cold work must then be increased. A completely discontinuous structure was not obtained by annealing the unworked alloys, although the intragranular distribution of the excess constituent was radically altered.

Recrystallization is necessary to transform the intergranular films into discrete particles. The shape and size of the molten tin particles are determined by the relative interfacial energies and movement of the aluminum crystals during recrystallization and grain growth. Tin particles totally enclosed within grains tend to be globular.

HIGH-TEMPERATURE TENSILE TESTS

It has been shown above that unfavorable tin distribution can be transformed to discrete particles by cold working and recrystallization. When the tin is in the form of continuous films the ductility of the alloys falls as the testing temperature is raised.[4] The contrary effect is to be expected when the tin is present as discrete particles, since the properties of the matrix will then be more important. In fact, the change of ductility with temperature has been used as a semiquantitative measure of the success of the process in alloys of different tin contents.

Our high-temperature tests were performed on water chill cast billets with an aluminum: copper ratio of 98:2, containing up to 60% Sn, which were cold forged and recrystallized at 660° F. (350° C.) and air cooled. Results of tensile tests at 20, 100 and 200° C. are given in Fig. 9. Figures for elongation, placed at respective points in this diagram, show improved ductility with increasing test temperatures in alloys containing up to 40% tin. Exactly analogous results were obtained when the copper was replaced by 2.5% of silicon.

WROUGHT AL-SN-CU ALLOYS

Aluminum-tin alloys containing copper are susceptible to heat treatment. Results of tensile tests at room temperature on such alloys are shown in Table VI. The samples were cold worked but were otherwise treated normally. No quench cracking occurred. Tin sweat appeared but was limited to the surface

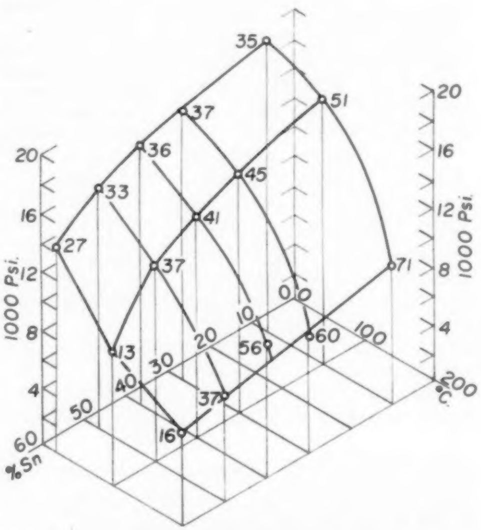

Fig. 9 — High-Temperature Tensile Tests on Ternary Alloys Based on 98-2 Al-Cu Ratio. Figures represent elongations. Test bars cold forged from 2¼ in. diameter to ¾ in. square, and annealed 1 hr. at 660° F. (350° C.)

layers; it would be immaterial when followed by a machining operation.

Table VI and similar tests on 96-4 Al-Cu alloys show that the properties when annealed are almost independent of the tin content. (It should be remembered that very small quantities of tin, of the order of 0.05%, markedly increased the properties after artificial aging.[4, 8])

Representative microstructures are illustrated by Fig. 10 to 13. The forged alloy showed elongated dendrites and continuous films, Fig. 10. After recrystallization at 660° F. (350° C.) the tin phase was present as small angular particles, Fig. 11.

A more equiaxed distribution was achieved in the alloys annealed at 930° F. (500° C.). Alloys containing 40% of tin then possessed a semi-continuous network, as shown in Fig. 12, but the network was more or less complete when 50% tin was present.

The molten tin particles move during heat treatment in accordance with the requirement of minimum interfacial energy — mechanically, also, as they are displaced by the recrystallizing aluminum solid solution. The insoluble constituents tend to be absorbed by the tin during this process, leading to the microstructure shown in Fig. 13.

Table VI — Tests on Cold Worked and Heat Treated Alloys Based on 97-3 Al-Cu Ratio

Property	Tin Content			
	None	10%	20%	30%
	Annealed 1 Hr. at 660° F. (350° C.)			
0.1% proof stress	6,000	6,700	6,300	6,700
Ultimate stress	22,200	22,000	21,500	23,700
Elongation	36%	33%	33%	29%
1 Hr. at 930° F. (500° C.), Water Quenched, Aged 16 Hr. at 330° F. (165° C.)				
0.1% proof stress	25,500	20,600	22,600	18,400
Ultimate stress	38,500	32,000	32,900	27,800
Elongation	20%	16%	11%	16%
	1 Hr. at 930° F., Water Quenched, Aged 14 Days at 70° F.			
0.1% proof stress	7,400	7,800	8,900	6,700
Ultimate stress	29,100	26,000	26,000	23,700
Elongation	35%	31%	24%	29%

TIN DISTRIBUTION DOMINATES PROPERTIES

Analysis of our test results and corresponding microstructures provide a very strong confirmation of the dominant influence of the tin distribution. Discrete tin particles are associated with good values of ductility. Even after high-temperature annealing of alloys with high-tin content (which results in large tin particles) the elongations are above 20%. However, films are harmful to this property.

The ability of the alloys to withstand quenching without cracking makes it possible to provide a range of properties for alloys with a wide variation in tin content. For example, an alloy with 45% tin gave a maximum stress value of 27,000 psi. and 18,000 psi. for the 0.1% proof stress. In the 30% tin alloy the hardness may vary from 20 Vickers for the pure binary to 80 for the fully heat treated 3% copper ternary alloy. Within reason, the tensile properties required may be obtained by a suitable choice of alloy composition and heat treatment.

The tendency of the elongation values to fall with increasing tin content probably sets the

Microstructure of Forged and Heat Treated Al-Sn-Cu Alloys. 150× except Fig. 13, which is 600×

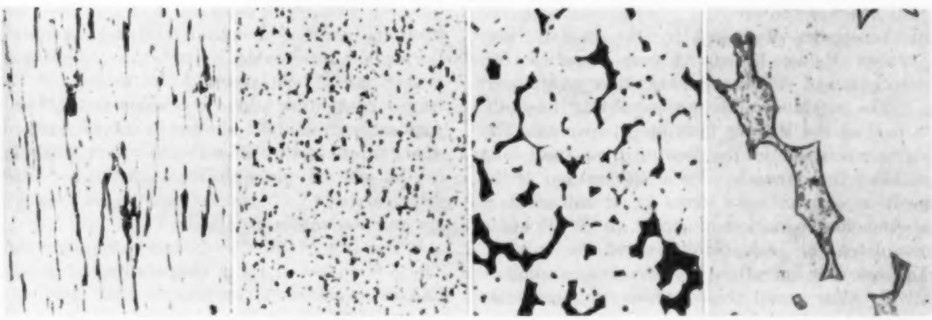

Fig. 10 — 1.6% Cu, 20% Sn, Cold Worked From 2¼ In. Dia. to ¾ In. Square; Not Annealed

Fig. 11 — Same as Fig. 10, Annealed 1 Hr. at 660° F.

Fig. 12 — 1.2% Cu, 40% Sn, Cold Flattened From 2¼ to ¾ In. Annealed 1 hr. at 930° F.

Fig. 13 — 2.1% Cu, 30% Sn, Treated as Fig. 12 600×. Etched in 0.5% HF

upper limit at 30% for alloys undergoing full heat treatment. Excessive bleeding of the cast billets during annealing prior to cold working occurs when the tin exceeds 40%, but it is of interest to record that forgings have been made containing 60% of tin.

FATIGUE STRENGTH OF SELECTED ALLOYS

Alternating bending tests were made with machines of the rotating load type wherein the specimen is stationary; its temperature can therefore be more accurately maintained and measured. The machines themselves were built to the design developed by the British Non-Ferrous Metals Research Assoc., and a full description of them has already been published.[9]

The machines may be regarded as the counterpart of the Wohler machine in reverse. The stress variation in the two is the same, each point on the circumference of the test bar at the position of maximum stress being subjected to a sinusoidal variation of stress, the cycle being completed for each revolution of the spinner. The speed of operation is 3000 r.p.m. — comparatively slow — and this explains why the tests described were discontinued at 10^8 revolutions.

To obtain a standard for comparison, tests were carried out on two commercial bearing alloys containing approximately 6% Sn, 1% Cu, 1% Ni, balance Al, known in Great Britain as AC9 and in the United States as Alcoa 750.

In the cast condition this alloy had Vickers hardness of 69.6. Its fatigue strength (from S-N curves which flattened out at about 50×10^6 cycles of stress) was 8800 psi. at room temperature and 9000 psi. at 300° F. (150° C.). In a similar alloy in the slightly cold worked condition the hardness was 55.9, and fatigue strength was 8900 psi. at 70°, and 7400 psi. at 300° F.

For a bearing material these fatigue values are encouragingly high but they are unfortunately coupled with high hardness — about three times that of tin-base babbitt. Room temperature hardness of a bearing alloy intended to run on an unhardened journal should not be greater than 30 on the Vickers scale. The obvious way of softening these aluminum-base alloys is to reduce their content of hardening constituents and possibly to increase their tin content, if this could be done without at the same time reducing the fatigue strength to a point where the alloys would have nothing to offer in this respect over existing soft bearing materials.

Table VII — Fatigue Tests on Aluminum-Base Alloys Containing 30% of Tin

Composition of Alloy	Treatment	Testing Temperature °F.	Testing Temperature °C.	Fatigue Strength, Psi.	Vickers Hardness
70% Al 30% Sn	Cold worked; annealed 1 hr. at 660° F.	70 300	20 150	±3500 ±3000	22
69% Al 30% Sn 1% Cu	Cold worked; heat treated 1 hr. at 930° F.; quenched; aged for 16 hr. at 330° F.	70 300	20 150	±6500 ±4600*	27
67% Al 30% Sn 3% Cu	Cold worked; annealed 1 hr. at 660° F.	70 300	20 150	±7100 ±4600	37
67% Al 30% Sn 3% Cu	Cold worked; heat treated 1 hr. at 930° F.; quenched; aged for 16 hr. at 330° F.	70 300	20 150	±9800 ±5400†	80

*S-N curve not horizontal; endurance limit estimated at ±4400 psi.
†For 10^8 reversals; alloy probably changing by overaging during test.

A comprehensive program of fatigue testing on high-tin alloys was therefore arranged. The work at 20 and 150° C. on the binary aluminum-tin and ternary aluminum-tin-copper alloys, all containing 30% tin, is now complete. All tests were done on material that had been cold worked and heat treated to break up the primary intercrystalline network. In addition, the effect of heat treating the matrix of the copper-containing alloys was examined. Microscopical examination showed a fairly uniform distribution of the tin and not much variation in the size of the individual particles. Tests were carried to 10^8 reversals of stress. Results are summarized in Table VII.

Two important observations were made: *(a)* The S-N curves at room temperature in general had flattened out at around 50×10^6 reversals, whereas the curves for high temperature were still falling at 10^8 reversals; *(b)* the tendency for the high-temperature curves to flatten out at 10^8 reversals was much less pronounced for the

copper-containing alloys, fully heat treated, than for the remaining materials. Thus, the test values at 20° C. in Table VII may be accepted as truly representing the fatigue properties of the materials at that temperature, but the values recorded at 150° C. are all too high — yet only significantly so for the fully heat treated ternary alloys.

This effect is almost certainly connected with the well-known aging characteristics of magnesium-free aluminum-copper alloys containing tin. Overaging (with consequent loss of tensile strength) is likely to occur after some days at 300° F. (150° C.).

COMPARISON WITH BABBITT

The fatigue strength of a typical tin-base babbitt may be taken as about ±4000 psi. at room temperature and ±2200 psi. at 100° C.; the room-temperature hardness is around V.P.N.24. Its fatigue strength at 300° F. (150° C.) is unknown, but (bearing in mind its low melting point and remembering that its tensile strength diminishes by one third and the modulus of elasticity by one half on heating from 100 to 150° C.) it would certainly be safe to assume that the fatigue strength of babbitt at 150° C. would be well below ±2200 psi. The lowest result in Table VII — namely ±3000 psi. for the 30% tin binary alloy — represents a very substantial improvement in hot fatigue strength (at working temperatures) as compared with that of babbitt — at least double. When it is borne in mind that this alloy is no harder than babbitt, its endurance is all the more encouraging.

Addition of copper increases the fatigue strength and hardness. With 3% copper the matrix of the Al-Sn alloy can be age hardened in the same way as alloys of the duralumin type; fully heat treated it may be V.P.N.80 hard.

Addition of 1% copper to the 30% tin alloy raises the fatigue limit by two thirds, and only slightly increases the hardness, even after full heat treatment. As already explained, this is one instance where 10^8 reversals of stress are not sufficient to establish the true endurance limit at 150° C., and in practice the alloy would not be expected to withstand indefinitely a stress quite as high as ±4600 psi., the value recorded in Table VII. By extrapolation of the curve the fatigue limit at 300° F. (150° C.) is believed to be just below ±4400 psi.

With 3% copper the test results depend markedly on the matrix of the alloy. Recorded fatigue values for a soft matrix are little different from those for the heat treated 1% copper alloy, while there is the disadvantage that hardness has been increased to V.P.N.37. A full heat treatment increases the room-temperature fatigue strength about 25%. On a basis of 10^9 cycles, however, it is estimated that the fatigue strength at 150° C. would be nearer ±4900, rather than ±5400 psi., reported in Table VII. Also, the form of the fatigue curve suggests that it will still be falling at 10^9 reversals, indicating that the material is actually overaging while the test is proceeding. When its high hardness is considered, this alloy is clearly unattractive as a bearing.

GENERAL DISCUSSION

The importance of controlling the tin distribution has been amply confirmed by our studies. Tin has previously been limited in commercial alloys to 6 or 7%, but it could be considerably more in cast alloys without harming mechanical properties at the working temperature. Close control of the casting conditions would be needed, and this might limit castings of high tin content (15%) to simple shapes. Certainly, the practical upper limit in cast alloys is twice the tin content now used commercially.

Cold working and recrystallization provides discrete particles in alloys with five times the tin content of present commercial bearings based on aluminum. A good distribution of tin particles is readily obtained with 30% Sn. The tin particles are finer the greater the degree of cold work and the lower the recrystallization temperature. Alloys containing copper are age hardenable and could be used for massive bearings, although the optimum composition still has to be worked out. Binary aluminum-tin alloys are suitable for use as backed bearings and are being investigated for this purpose.

Alloys containing 30% tin, with or without 1% copper, offer a combination of fatigue strength and softness hitherto unknown in bearing materials. Such soft materials would best be used as a lining, bonded to stronger backing; some progress has been made in bonding techniques. Alloys containing more copper are less attractive, owing to their greater hardness.

The good antifriction properties of tin in a cheap matrix such as aluminum promise new bearing materials with improved properties. This prediction is made on the basis of a desirable combination of hardness, strength, and fatigue resistance, and not on tests of bearings in service. It would therefore be most unwise at this stage to jump to conclusions. Bearing tests, using machines of the Underwood type, are just being started, and judgment must be reserved.

Deep Welding— a New Method of Oxy-Acetylene Welding

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THE LEAST METAL NECESSARY for a weldment is that amount required for a joint having non-beveled, relatively close edges. While such a gap should be the most economical, it is difficult to fuse the bottom edges (the root). This difficulty can be overcome by adjusting and applying the oxy-acetylene flame in such a manner that its action is most effective at these root edges. To insure such efficiency, the edges should be near the source of heat — specifically, close to the cone of the flame and, in particular, the actual *tip* of the cone, where the heat is most concentrated — and further, the largest possible volume of hot gases should reach the root edges at the bottom of the joint.

A new process of "deep welding" has been developed by the author to accomplish the above objectives. It increases welding speed by 50% and lowers the consumption of welding rod and gases. It introduces the flame deep into the gap, which is a butt joint, at right angles to its length, as seen in Fig. 1. By this means the cone of the flame (and in particular its tip) is brought close to the root edges. The tip should reach down at least half the thickness of the plate. Since the flame is moved at right angles to the joint, more hot gases are forced to the bottom edges than if the flame were inclined at an angle. Deep welding requires a concentrated flame (narrow and pointed) to fit into narrow gaps. It also requires a "harder" flame than that used in other welding methods — that is, a flame with a higher pressure.

To sum up, then, the method calls for a deep, hard and concentrated flame, directed at right angles to the length of the joint, and also requires a butt joint — plates with nonbeveled edges. These features reduce the material that must be fused, but increase the capacity of the flame to fuse both this material and the requisite part of the abutting edges.

The welding rod must be brought close to the cone of the flame and thus deep into the joint, and moved with well-defined circular or oval movement in the melted material, gradually moving forward. This puddling is to insure an evenly filled weld and to prevent the formation of gas bubbles in the fused material.

The size of the tip (welding flame) must be adequate to furnish sufficient molten material for a well-fused and filled weld.

The most obvious advantage of deep welding is speed combined with a smaller cost of gas and welding rods. It is clear that when the flame is localized deep down in a narrow gap with straight sides, surface absorption of heat from the flame, both by conduction and by radiation, must be good.

To illustrate the efficacy of the method a number of plates of various thicknesses were deep welded. The amount of gas and rod consumed, gap width and time taken in the welding

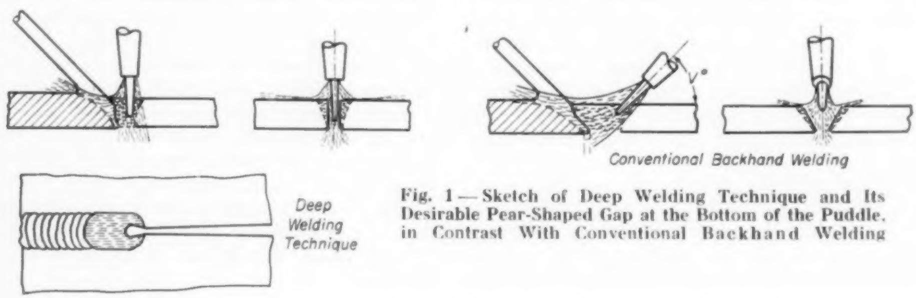

Fig. 1 — Sketch of Deep Welding Technique and Its Desirable Pear-Shaped Gap at the Bottom of the Puddle, in Contrast With Conventional Backhand Welding

Fig. 3 — Operator Using Depth-Setter and Weld-Rod Holder in Deep Welding a Circular Seam. Note vertical direction of welding blowpipe

were carefully noted. The test welds were made on soft St37 steel (tensile strength 37 kg. per sq.mm. minimum or 52,500 psi.). Pieces 15 to 20 in. wide, 20 in. long, were welded, the weld being 20 in. long. The large width of plate was selected in order that the heat absorption should not be less than in normal production. Actual time taken for the welding is reckoned from the moment when molten material commences to fill up the gap until the flame and rod are finally removed. Replacements of rod are thus included in the time. There were no other interruptions of any importance. A rod-holder was used during the operation (see Fig. 3).

The curves in Fig. 2 compare the results. Backhand welds in $\frac{3}{16}$ in. and thicker were beveled to 30°, making a V of 60°. Width of gap was 0.4 times plate thickness. These values, as well as the rod sizes, were in accord with standard specifications. The flame was neutral in all cases. All welding was done manually and was of the highest workmanship, being well filled out and properly fused throughout. Three sample welds were made on each plate thickness, and mean values of these three tests are plotted in the diagram.

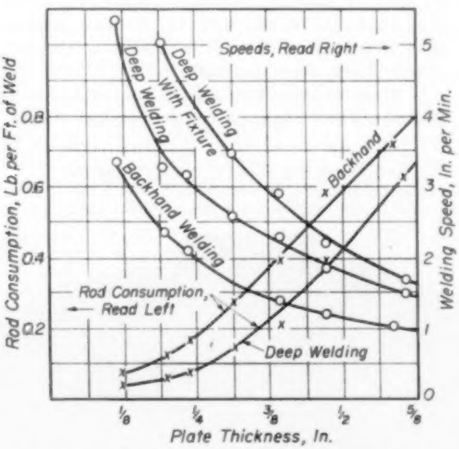

Fig. 2 — Welding Speed and Rod Consumption for Deep Welding, in Contrast With Conventional Backhand Welding. Acetylene consumption is closely proportional to rod consumption; and the conversion constant is about 16. For example, ½-in. joint, deep welded, requires 0.43 lb. rod per ft. of weld (scaled from curve) and 0.43 x 16 or 7.0 cu.ft. of acetylene per ft. of weld

From the curves for welding speed in Fig. 2 as a function of plate thickness it will be seen that the average speed for plates ⅛ to ⅝ in. thick is approximately 55% greater with deep welding than with backhand. Curves in Fig. 2 also show rod consumption; deep welding uses about 25% less. Virtually the same saving is obtained in acetylene. The new method therefore leads to a substantial improvement in economy, as shown in Table I.* Overhead is figured as 50% of the normal labor rate (31¢ per hr.). Acetylene is figured at 1.5¢ per cu.ft.; oxygen at ½¢ per cu.ft.; welding rod at 6¢ per lb.

Table I — Cost Comparisons, $ per Ft. of Weld

Plate	Deep Weld	Backhand
⅛ in.	$0.03	$0.05
$\frac{3}{16}$	0.04	0.08
¼	0.06	0.11
$\frac{5}{16}$	0.08	0.15
⅜	0.11	0.19
½	0.21	0.31
⅝	0.33	0.45

The figures show that deep welding cuts costs by about one third, and these figures are not the limit. A sample weld was made on

*Editor's Note — Scaled from curves and converted into American units. 1 *krona* equals 19.35¢.

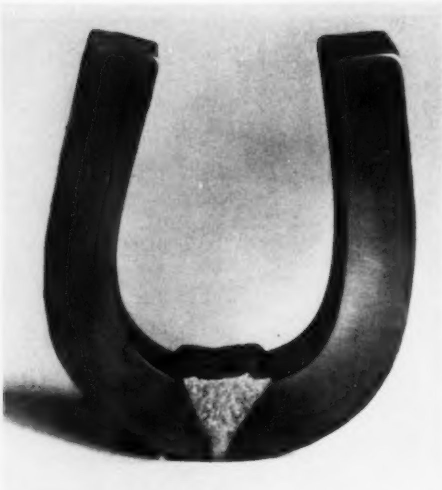

Fig. 4 — Cold Bend of Section Cut From Deep-Welded Joint in ⅝-In. Plate (About Full Size)

$\frac{5}{16}$-in. plate at a speed of 3.8 in. per min. (whereas the average in Fig. 2 calls for 2.6 in. per min.) and gas consumption of 2.1 cu.ft. per ft. of weld (whereas the average curve of Fig. 2 calls for $0.15 \times 16 = 2.4$ cu.ft.).

Welding speeds can be increased with larger torches using more gas than usual. However, with low-skilled operators the increase in speed will not be in proportion to the increased gas consumption. Unsteadiness in handling the torch, raising or lowering the flame, is relatively more important where larger quantities of gas per unit of time and plate thickness are concerned. To take advantage of larger welding tips without waste of gas, a special tool — a depth-setter — has been developed which permits the flame to be moved along the joint perfectly steadily. In this device a wheel precedes the flame along the joint, and the torch rests on this wheel. A simple finger control steers the wheel. Figure 3 shows an operator using this equipment.

The upper curve in Fig. 2 shows the speed attainable with the depth-setter. Average welding speeds were 30% over ordinary deep-welding speeds and 100% over backhand welding speeds. The acetylene consumption was also increased on the order of 70%.

Deep welding localizes and concentrates the heat at the plate edges; this means that less heat is drawn back into the adjacent plate, and that the weld itself is cooled more rapidly than in conventional welding, thus reducing grain growth and increasing the mechanical strength of the weld metal. Tests have repeatedly corroborated these facts. A correctly made deep weld will readily stand the cold bend test, seen in Fig. 4, a photograph of a joint in ⅝-in. plate. This section also shows the proper welt (reinforcement) on both top and bottom surfaces.

Warpage will be less with deep welding because less heat penetrates the material. The smaller amount of heat means less fatigue of the operator, thereby improving his efficiency.

It will be observed from Fig. 4 and 6 that the penetration is very great. Deep welding thus eliminates cold shuts along the faces of the groove, and as long as due care is taken to fuse the bottom edges it is certain that the faces higher up will be fused. The edges at the bottom will be melted into a pear-shaped enlargement of the gap, as sketched in Fig. 1. This opening should be maintained at constant size and kept immediately beneath the flame. The width of the enlarged gap can be verified by examining the underside of the weld on completion; if it is uniformly enlarged, one can rest assured that the material is fused throughout. Because the quality of a weld can be judged from the appearance of its root-side, the Swedish authorities have waived X-ray examination of deep-welded tanks for some uses.

X-ray examination shows deep welds to be noticeably free from porosity and other defects.

Fig. 5 — Partly Finished Joint in Small Pressure Vessel (Gas Container) Showing Line-Up of Joint, Large Gap Under Flame, and Completed Weld

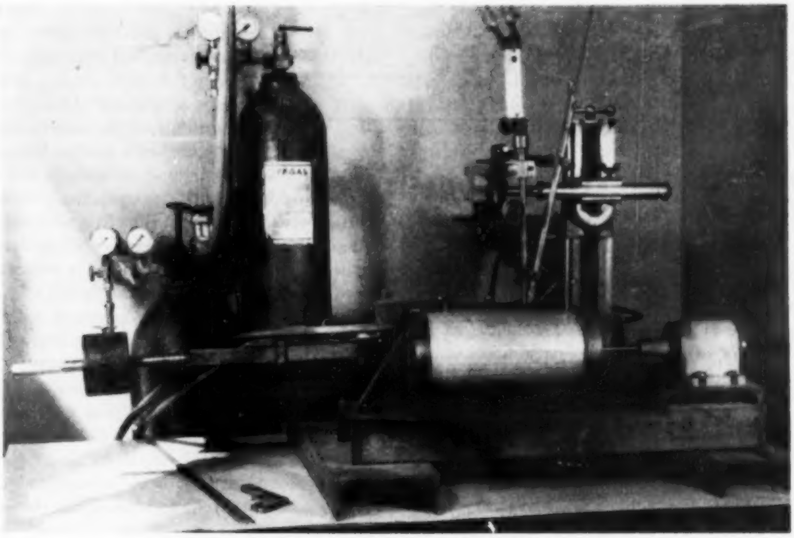

Fig. 6 — Machine for Deep Welding Small Cylinders With ⅛-In. Wall. Speeds, up to 12 in. per min.

The mean rating, for example, for 313 deep-welded jackets submitted for X-ray examination to the Swedish Technical X-ray Institute is 4.4 out of a possible 5.0.

APPLICATIONS IN SWEDEN

Deep welding finds many applications in Sweden. Figure 5 shows a joint, partly made, on the domed end of a small high-pressure gas cylinder. These cylinders, used for oxygen for anesthetic and other purposes, range in volume from one pint to 0.9 cu.ft., and have wall thickness from 2 to 6 mm. (12 gage to ¼ in.). The material is alloy steel similar to S.A.E. 4130 of the following nominal composition: 0.25% C, 0.70% max. Mn, 0.35% Si, 1.0% Cr and 0.20% Mo.

The sides are of seamless tube. Covers and bottoms are of domed design and welded on, and a nipple is welded into the cover for the gas valve. Thus, there are two main welds around the circumference as well as the small nipple weld. The parts are assembled by small tack welds. The cylinders are then supported on rollers which rotate slowly during the process. The worker can stop the rotation to suit the speed of the operation by a pedal.

This steel has a higher surface energy when liquid than unalloyed steel. As a result the molten metal does not run down to form a ridge beneath the weld-root as quickly. In order to get a ridge (underside reinforcement) a larger hole must be retained immediately beneath the flame than is otherwise necessary.

After welding is completed the cylinders are normalized and air cooled.

The cylinders are designed for a working pressure of 2100 psi., and are tested to 3200 psi. One chosen at random out of every batch of 200 is tested to destruction, the pressure necessary being of the order of 8500 to 10,000 psi. So far, no weld has broken at this pressure. To date, about 100,000 cylinders of all types made from this alloy steel have been deep welded.

The process is particularly suited to machine welding. Figure 6 shows a welding machine for cylinders with ⅛-in. wall. To melt the welding rod quickly an extra flame is applied. Traveling speeds are much higher than with hand welding, running up to 12 in. per min.

Deep welding of plate thicknesses over ⅜ in. has been done by the same techniques as the thinner gages. Lately a special torch has been developed for these heavier thicknesses. In this torch there are two flames placed in tandem. One flame is always about $\frac{3}{16}$ in. ahead of the actual welding flame; it preheats the edges. By this means a more diffused heat is obtained so there is better control of the molten material. Control of molten material presents no problem with plate thinner than ⅜ in., consequently single tips are used.

Correspondence

Surface Hardening of Nodular Cast Iron With High-Frequency Currents

OSAKA, JAPAN

High-frequency hardening of cast iron surfaces is usually difficult and unsatisfactory because *(a)* cast iron is a poor heat conductor as an aggregate; *(b)* excess ferrite easily precipitates from the austenite on cooling; *(c)* current densities induced in the two main microconstituents, graphite and ferrite, are quite different, thus causing superheated regions; *(d)* in high-phosphorus iron, steadite, the fusible Fe-C-P eutectic, may appear.

It is obvious that a reasonably uniform austenite can form much more readily from a fine pearlite with well-disseminated ferrite veins (medium steel) than from a matrix consisting of coarse ferrite and graphite (black-heart malleable) — if for no other reason than the much larger distances over which the carbon atoms must diffuse. An induction hardened malleable iron is shown in Fig. 1. Much of the carbon was undissolved; around these carbon masses are shells of ledeburite (eutectic of iron carbide and saturated austenite, more or less transformed) and martensite. Original hardness of this iron was Rockwell C-5; maximum surface we were able to get with 20,000 or 30,000-cycle current was C-18, in a layer about 2 mm. deep. One would say, therefore, that the carbon content of the martensite is, on the average, pretty low.

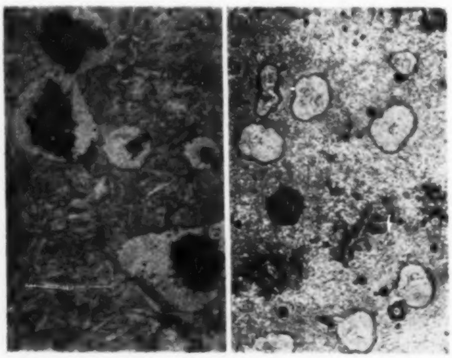

Fig. 1 (Left) — Induction Hardened Shell of a Black-Heart Malleable Iron Bar. Fig. 2 (Right) — Induction Hardened Nodular Cast Iron. Both 250 ×. Microsections prepared and photographed by T. Kusakawa of the castings research laboratory, Waseda University, Tokyo

Nodular cast iron would doubtless react to induction hardening much better, especially if the microstructure is the frequent mixture of rounded graphite particles within fairly thin spheres of ferrite, the whole in a matrix of very fine pearlite. Intense and quick heating by induction currents would produce a fairly uniform, high-carbon austenite, the least chance of incipient melting from hot spots, and — on quenching — a uniform martensite of high hardness and a structure free from cracks or micro stress raisers.

This we find, indeed, to be true. Figure 2 is the microstructure of such a hardened case. Its original hardness was about C-25; the induction hardened surface layers, about 3 mm. deep, are now C-60 hard.

Pearlitic malleable is also readily hardenable by induction heating to C-55.

TAKAO TAKASE
Head of Metallurgical Department
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Russian Metallurgical Texts

SWANSEA, WALES

Dr. Zapffe has presented a lively and most interesting commentary on current metallurgical literature from the U.S.S.R. in last month's *Metal Progress*. I feel, however, that some of his impressions and opinions based thereon call for brief supplementary comment.

In the first place let us see why Russian technical books are so "cheap". Consider a typical example: I have just purchased Okorokov's "Electric Furnaces for Melting Steel", 1950, and have paid for it 8 shillings and sixpence, or just over $1.00 in U. S. currency. The original price impressed in the left-hand corner on the back cover is 19 *rubels* 10 *kopeikas*, and since the official rate of exchange is about 5 *rubels* per dollar, this book should really cost about $4.00. Where is this difference coming from? Obviously, from the pocket of the patient Russian taxpayer.

Take it in another way and the spuriousness of this mock-cheapness will come out clearer still. In a minor job which carries in America a salary of $250 per month, a Russian

engineer will get about 600 *rubels*. The price of the book is therefore less than 1/200 of the American's monthly salary but as much as 1/30 of the Russian's.

This peculiar discount is doubtless a part of the official propaganda policy. Since technical literature forms a minor part of the stock held by the approved book stores, one might wonder whether these are not considered simply as a kind of fly-paper for customers who may later buy "The Short Course of History of the All-Union Communist Party", or as it is called in Russia, "The Fool's Bible". The discount on this book is probably still greater.

I willingly confirm that many Russian textbooks are really very good and useful, but as far as I can see, there is little original in them. The reason why they are so orderly is closely connected with the Russian system of technical education; most of these books are approved university manuals. Wire drawing or stamping, for example, is treated in British or American texts on physical metallurgy in a couple of pages of purely descriptive character. In Russia, on the other hand, one can take a specialized course devoted entirely to such subjects, expanded so that special comprehensive textbooks are required. (Personally, I think that technical education in the U.S.S.R. is sound and very efficient, but I cannot go into details in this brief communication.)

One should not judge the quality of Russian technical books by their degree of saturation with advanced mathematics. While the large number of triple integrals and differential equations is by itself highly impressive, a close examination of the matter will reveal that many of the resulting formulas (very often exceeding 3 in. in length) usually are a smoke screen hiding a vacuum. The number of empirical constants in such equations renders this sky-blown theory entirely pointless — in fact, nobody takes much notice of them, even in Russia, except students and candidates for advanced degrees.

As typical examples one can look up Taits' "Technology of Heating Steel", 1950, and, as I mentioned in my letter published in *Metal Progress* for December 1950, Dobrokhotov, who designed the Mariupol furnaces, was such a brilliant mathematician that nobody could prove his theories wrong until these monsters had been built and failed to produce.

The small number of references to foreign work, noted by Dr. Zapffe, is easily understood. If, say, Ivanov has written a book on stainless steel in 1936 and quoted Monypenny, this is sufficient. When Petrov is writing on the same subject in 1951 he does not need to quote Monypenny, since not only is Ivanov reliable enough, but additional glory is added to the scientific traditions of the Red Fatherland by ignoring any indebtedness to a foreigner. Recent books (unless they are reprints) and particularly those written since 1948 contain almost exclusively references to Russian work. This is simpler and safer!

Finally, if the Russians really possess such excellent scientists, engineers, and literature, the following questions should not arise:

1. Why have they translated as late as 1948 Seitz's 1943 "Physics of Metals" and Barrett's 1943 "Structure of Metals"? Neither could be considered as up-to-date at the time of translation, and yet it was apparently worthwhile to bring them to Russian metallurgists.
2. Why does the 1949 book on induction heating by Lozinski (a very good book, by the way) contain, as an example of its use in a large forging plant, a shabby reproduction of equipment in the Mullins plant from an American magazine, and not of Russian plant?
3. Would Loskutov's recent pot-boiler on the metallurgy of zinc ever have been translated into German, if the German publisher were in Munich and not in the Soviet Zone?
4. Why does the Molotov Automobile Works in Gorki still produce the 1928 model 1.5-ton Ford truck, without any changes?

These comments must not be considered as a criticism of Dr. Zapffe's review. They are put forward merely with the aim of showing that overestimation of Russian industrial power and intelligence is equally as dangerous as the opposite. From numerous recent publications it appears that the first is now very common.

N. H. POLAKOWSKI
University College

Corresponding or Homologous Temperatures

PARIS, FRANCE

Even though "room temperature" has no physical significance, it enters into all our comparisons of properties of different materials for obvious practical reasons. Still, its use as a common point of reference tends to mask those general relationships that one seeks to discern and establish between the properties of metals.

The centigrade scale of temperatures is no better in this respect. This scale, based on the

freezing and boiling points of *water*, can have no relevant bearing on the behavior of *metals*. A proper comparison would be based on thermometric scales related to the behavior of each metal — running, for example, from zero at absolute zero to, say, 100 at its melting point.

This method of construction gives what may be called "corresponding" or "homologous" temperatures. A corresponding temperature thus has the same numerical value at the same fraction of the absolute temperature of melting.

Corresponding temperatures bring out several simple relationships. Tammann pointed out long ago that the absolute temperature of recrystallization is one half the absolute temperature of fusion. In other words, the corresponding temperature of recrystallization is 50.

Corresponding temperatures should reveal some simple relationships among the elastic moduli of metals, for the melting point can be considered as the temperature at which it reduces to zero. We have already pointed out that the elastic modulus E at room temperature is proportional to the atomic value V of the metal, provided a correction term for its melting point T is considered. (E is approximately equal to $1000 + 650T/V^2$.) Again, Mallock claims that the ratio of the modulus at absolute zero to the modulus at 0° C. is equal to the ratio of the melting point expressed in degrees kelvin to the melting point expressed in degrees centigrade. If this is true, and if the melting point of a metal is expressed as a corresponding temperature — that is, 100 — then the temperature coefficient of elasticity of any metal is equal to its elastic modulus at absolute zero.

All metals have the same coefficient of expansion if corresponding temperatures are used (neglecting the ferromagnetic elements) since all metals expand about the same amount from absolute zero to their melting point. The ferromagnetic metals are an exception to this generalization because of the perturbations in the expansion curve below the Curie point.

The looseness of the term "hot tests" can be avoided if one defines them as being performed above the recrystallization temperature — or at a corresponding temperature above 50. Creep curves become comparable for all metals if compared on the basis of corresponding temperatures, as may be seen in Andrade's and Orowan's work.

Further examples, such as diffusion rates and calcination rates, could be cited but this is hardly necessary. The fruitfulness of this approach is obvious.

ALBERT M. PORTEVIN

The Festival of Britain

BIRMINGHAM, ENGLAND

One of our lathes must have been imbued with the festival spirit when it produced this turning of 18-8 stainless steel during a parting operation at 215 ft. per min. and 0.005-in. feed with a "Stellite 100" tool.

M. RIDDIHOUGH
Technical Manager
Deloro Stellite Limited

Acceptance Test for High Speed Tools

ILFORD, ESSEX, ENGLAND

At the Editor's request, I am sending a procedure for testing high speed steel tools, a test used in my work at Ford Motor Co. Ltd. of England for 20 years, and also for many years considered standard by the British Admiralty. It is capable of separating the sheep from the goats among shipments of heat treated tools made from the British Standard analysis, 18% W, 4% Cr, 1% V.

This recommended practice for high speed is briefly as follows:

1. Test each piece for hardness, rejecting all having a Rockwell hardness below C-64.

2. Select 5 to 10% of the accepted tools at random (according to size of lot), heat them in

a salt bath for 1 hr. — more, if the tools are large — at 685° F. ±10°.

3. Cool and retest. If any are softer than before, treat all tools as in 2, and reject any that lose hardness. They are tools which have not been properly treated by the manufacturer.

JOHN GARLAND
Tool Room Foreman (Retired)
Ford Motor Co. Ltd.

Carbide Phase in Tempered Steel

NEWCASTLE UPON TYNE, ENGLAND

Readers of *Metal Progress* interested in the nature of the changes when quenched steel is tempered, and who have read Professor Guy's abstract in the June issue (p. 878) of the Russian paper written by M. P. Arbuzov ("The Crystal Structure and Particle Size of the Carbide Phase in Tempered Steel"), may wish to know about my own concurrent work on the same subject at the laboratories of the British Iron & Steel Research Assoc., and at Cavendish Laboratory in Cambridge, England. Results will be given in full in the forthcoming September issue of the *Journal* of the Iron and Steel Institute ("Structural Transformations in the Tempering of High-Carbon Martensitic Steels") but the following summaries of the work have already been published:

"Results of Further X-ray Structural Investigations of the Iron-Carbon and Iron-Nitrogen Systems and of Related Interstitial Alloys", in *Acta Crystallographica*, V. 3, 1950, p. 392 to 394.

"New Interstitial Alloy Phases Relating to the Surface Hardening of Steel", in *The Australasian Engineer* for November 1950, p. 55 to 61.

Arbuzov's observations are similar to the ones recorded in these 1950 papers of mine, and relate to what may be called the third stage of tempering. Our respective interpretations are qualitatively the same. Arbuzov's work is incomplete, however, in that there is no mention of the structural changes which occur during the first stage of martensitic decomposition.

(It may not be amiss to point out that the work of Antia, Fletcher and Cohen published in the *Transactions* of the American Institute of Mining and Metallurgical Engineers in 1944 showed that a hardened structure in high-carbon steel consisting of tetragonal martensite and retained austenite would undergo three changes during low-temperature tempering. While it is generally agreed that the second stage consists of the transformation of the retained austenite, the exact nature of the first and third stages has been in dispute, although they certainly are stages in the separation of cementite and the formation of cubic ferrite.)

My observations on the tempering of martensite may be summarized as follows:

New X-ray observations give direct evidence that the loss of tetragonality of martensite during the first stage of steel tempering is caused by the precipitation of a close-packed hexagonal iron carbide. A proposed name for it is "ε iron carbide", because of its structural similarity to "ε iron nitride". The ε iron carbide is formed as a coherent transitional phase in which relaxation of the Laue condition for X-ray reflection is a minimum in a direction normal to the (101) lattice planes. The existence of a simple orientational relationship between martensite and the hexagonal carbide is probable.

During the third stage of steel tempering, ε iron carbide transforms to give a fine dispersion of very thin platelets of cementite, with the planes of the platelets parallel to the (001) lattice planes of the cementite structure. The observed X-ray diffraction pattern is markedly different from that of high-temperature crystalline cementite, as the Laue condition is completely fulfilled only in directions parallel to the (001) plane and is relaxed in the [001] direction. Included among the strongest reflections are those corresponding to previously unidentified X-ray reflections observed by earlier investigators and ascribed by them to a new unknown iron carbide. With increasing tempering times, or at higher temperatures, the gradual growth and recrystallization of the cementite platelets are accompanied by a reduced strain in the matrix.

Each of the two stages of the transition of dispersed carbon in martensite to the iron carbide, cementite (corresponding to the first and third stages, respectively, of steel tempering) can take place by relatively small movements of iron atoms, and the precise nature of these movements is suggested in my publications cited above. The proposed structural changes are correlated with the well-known changes in hardness and specific volume of steel during tempering, and are supported by recent electron-microscope studies.

Cementite platelets similar to those observed in tempered martensites are also obtained in the low-temperature heat treatment of carbonyl-iron powders.

K. H. JACK
Chemistry Dept.
King's College, University of Durham
Formerly Senior Scientific Officer
British Iron & Steel Research Assoc.

Advertisement

ELECTROMET *Data Sheet*

Published by Electro Metallurgical Company, A Division of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y. In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario.

ALLOYS FOR THE STEEL, IRON, AND NON-FERROUS INDUSTRIES

BORON ALLOYS

PRODUCT*	NOMINAL COMPOSITION	USES
Ferroboron Min. 10.00% Boron Grade	Silicon........max. 1.50% Aluminum.....max. 0.50% Carbon........max. 1.50%	Increases hardenability of steel; also, for additions to malleable iron and aluminum alloys.
Min. 17.50% Boron Grade	Silicon........max. 1.50% Aluminum....max. 0.50% Carbon.......max. 0.50%	
Manganese-Boron	Boron........min. 17.50% Manganese...approx. 75% Silicon........max. 1.50% Carbon..........max. 3% Iron............max. 5%	Used to cleanse and deoxidize non-ferrous alloys.
Nickel-Boron	Boron..........15 to 18% Silicon........max. 1.50% Aluminum.....max. 1.00% Carbon.......max. 0.50% Iron..........max. 3.00% Nickel............Balance	Special boron alloy used principally for deoxidizing nickel and its alloys.
Boron Carbide	Boron..........45 to 50% Carbon ....45 to 50%	Deoxidizer for non-ferrous alloys.
Calcium Boride	Boron..........38 to 42% Calcium.........27 to 32% Carbon.........15 to 20%	Welding rod coating.
SILCAZ Alloy	Boron.......0.55 to 0.75% Silicon.........35 to 40% Calcium..........9 to 11% Aluminum.........6 to 8% Titanium........9 to 11% Zirconium........3 to 5%	A complex boron addition agent for increasing the hardenability of steel.

CALCIUM ALLOYS

PRODUCT*	NOMINAL COMPOSITION	USES
Calcium-Silicon	Calcium........30 to 33% Silicon.........60 to 65% Iron..........1.50 to 3%	Deoxidizer for quality ingot steel. Also used in high-tensile gray irons.
Calcium-Manganese-Silicon	Calcium........16 to 20% Manganese.....14 to 18% Silicon.........53 to 59%	A complex deoxidizer used widely in production of steel castings.
Calcium Metal Regular Grade	Calcium.............98% (Cylinders, Slabs, Cut Pieces, or Turnings)	Reducing agent in metallurgical applications, deoxidizer and degasifier for non-ferrous metals, particularly magnesium.
Distilled Grade	Calcium...approx. 99.90% (Irregular pieces from pea size to 14 in. lumps)	For special applications requiring calcium of very high purity.

CHROMIUM ALLOYS

PRODUCT*	NOMINAL COMPOSITION	USES
Low-Carbon Ferrochrome	Chromium......67 to 71% Silicon......0.30 to 1.00% Carbon (10 Grades) max. 0.03 to max. 2.00%	Production of stainless steels and high-temperature alloys requiring low carbon content.
High-Carbon Ferrochrome Max. 4.50, 5.00, or 6.00% Carbon Grade	Chromium......67 to 70% Silicon......... 1 to 2%	For production of engineering alloy steels and other alloy steels of moderate chromium content.
Max. 7.00% Carbon Grade	Chromium......66 to 69% Silicon......... 1 to 3%	
Min. 7.00% Carbon Grade	Chromium......65 to 68% Silicon......... 1 to 3%	
Nitrogen-Bearing Low-Carbon Ferrochrome	Chromium......67 to 71% Silicon......0.30 to 1.00% Carbon.......max. 0.10% Nitrogen....approx. 0.75%	For additions of nitrogen to improve properties of high-chromium steels.
"SM" Ferrochrome	Chromium......60 to 65% Silicon .... 4 to 6% Carbon.......... 4 to 6% Manganese..... 4 to 6%	A high-solubility chromium addition for steel or iron in either furnace or ladle.

CHROMIUM ALLOYS cont.

PRODUCT*	NOMINAL COMPOSITION	USES
Foundry Ferrochrome High-Carbon Grade	Chromium......62 to 66% Silicon......... 7 to 10% Carbon......... 5 to 7%	Developed especially for high-solubility ladle additions of chromium to improve composition and properties of cast iron.
Low-Carbon Grade	Chromium......50 to 54% Silicon.........28 to 32% Carbon.......max. 1.25%	
Chromium Metal Low-Carbon Grades	Chromium.......min. 97% Carbon ......max. 0.10% and 0.50% Iron............max. 1%	Production of wide variety of non-ferrous chromium-bearing alloys, including electrical resistance alloys and high-temperature alloys.
High-Carbon Grade	Chromium......87 to 90% Carbon......... 9 to 11% Iron..........max. 1.25%	
"EM" Ferrochrome-Silicon No. 1 Grade	Chromium......39 to 41% Silicon.........42 to 46% Carbon.......max. 0.05%	In production of stainless steels, these alloys are used to reduce metal oxides from the slag back into bath.
No. 2 Grade	Chromium......36 to 39% Silicon.........36 to 39% Carbon.......max. 0.05% Aluminum...... 7 to 9%	
"EM" Ferrosilicon-Chrome	Chromium......50 to 54% Silicon.........28 to 32% Carbon.......max. 1.25%	For adding chromium and silicon to steels containing up to 1 or 2 per cent chromium.
"EM" Chromium Briquets (Hexagonal Shape)	Chromium...........2 lb. Total Weight.......3⅛ lb.	For adding chromium to cast iron in the cupola.

COLUMBIUM ALLOYS

PRODUCT*	NOMINAL COMPOSITION	USES
Ferrocolumbium	Columbium.....50 to 60% Silicon..........max. 8% Carbon.......max. 0.40%	Stabilizer in austenitic chromium-nickel stainless steels. Also constituent of high-temperature alloys.
Ferrotantalum-Columbium	Columbium...approx. 40% Tantalum.....approx. 20% Cb+Ta ....min. 60% Silicon...........4 to 6% Carbon........max. 0.30%	Another stabilizer, used to supplement ferrocolumbium, in austenitic chromium-nickel stainless steels. Also used in high-temperature alloys.

MANGANESE ALLOYS

PRODUCT*	NOMINAL COMPOSITION	USES
Standard Ferromanganese Regular Grade	Manganese.....78 to 82% Carbon........approx. 7% Silicon..........max. 1%	Most common means of adding manganese to steel for both alloying and deoxidizing purposes. Also for counteracting sulphur in steel and cast iron.
Low-Phosphorus Grade	Manganese.....78 to 82% Carbon..........max. 7% Silicon..........max. 2% Phosphorus...max. 0.10%	
Low-Carbon Ferromanganese Low-Phosphorus Grade	Manganese......min. 90% Carbon.......max. 0.07% Phosphorus...max. 0.06%	Additions of manganese to steels of low-carbon specification, particularly stainless steels of 18 per cent chromium, 8 per cent nickel type.
Regular Grades	Manganese.....85 to 90% Carbon ....max. 0.07, 0.11 to 0.15, 0.30, or 0.50%	
Regular Grade (High-Silicon)	Manganese.....80 to 85% Carbon.......max. 0.75% Silicon......... 5 to 7%	
Medium-Carbon Ferromanganese	Manganese.....80 to 85% Carbon.........max. 1.25 to 1.50%	For making low- and medium-carbon manganese steel and Hadfield steel.
Silicomanganese Max. 1.50% Carbon Grade	Manganese.....65 to 68% Silicon.........18 to 20%	A versatile alloy useful as furnace block, deoxidizer, and also for making manganese additions to steel in the ladle or in the furnace.
Max. 2.00% Carbon Grade	Manganese.....65 to 68% Silicon.......15 to 17.50%	
Max. 3.00% Carbon Grade	Manganese.....65 to 68% Silicon.......12 to 14.50%	

*All of the alloys and metals listed are produced in the usual lump, crushed, or ground sizes, except where other special forms are indicated.

PRODUCT*	NOMINAL COMPOSITION	USES
MANGANESE ALLOYS cont.		
Low-Iron Ferromanganese	Manganese.....85 to 90% Carbon.....approx. 7.00% Silicon...........max. 3% Iron.............max. 2%	For high manganese additions to certain non-ferrous alloys, particularly aluminum.
Manganese Metal	Manganese......min. 96% Carbon.......max. 0.20% Silicon........max. 1.00% Iron..........max. 2.50%	Used both as deoxidizer and alloy in production of numerous non-ferrous metals and alloys.
"EM" Silico-manganese Briquets (Square Shape)	Manganese...........2 lb. Silicon...............½ lb. Total Weight........3½ lb.	For adding manganese (with silicon) to cast iron in the cupola.
"EM" Ferro-manganese Briquets (Oblong Shape)	Manganese...........2 lb. Total Weight.........3 lb.	For adding manganese (without silicon) to cast iron in the cupola.
SILICON ALLOYS		
50% Ferrosilicon		
Regular Grade	Silicon.........47 to 51%	Deoxidizer for most grades of killed or semi-killed steel. Blocking grade specially sized for maximum efficiency.
Blocking Grade	Silicon........47 to 51%	
Low-Aluminum Grade	Silicon.........47 to 51% Aluminum.....max. 0.40%	
65% Ferrosilicon Low-Aluminum Grade	Silicon....61.50 to 66.50% Aluminum.....max. 0.50%	Mainly for production of electrical sheet steel.
75% Ferrosilicon		Deoxidizer and alloy for production of high-silicon spring and electrical sheet steel. Graphitizing inoculant for cast iron.
Regular Grade	Silicon.........73 to 78%	
Low-Aluminum Grade	Silicon.........73 to 78% Aluminum.....max. 0.50%	
85% Ferrosilicon		Enables melter to add higher percentages of silicon without chilling metal in ladle. Graphitizing inoculant for cast iron.
Regular Grade	Silicon.........83 to 88%	
Low-Aluminum Grade	Silicon.........83 to 88% Aluminum.....max. 0.50%	
90% Ferrosilicon		
Regular Grade	Silicon.........92 to 95%	Permits large additions of silicon without harmful chilling effect.
Low-Aluminum Grade	Silicon.........92 to 95% Aluminum.....max. 0.50%	
Silicon Metal		
Regular Grade	Silicon.....min. 97 or 96% Iron.........max. 1 or 2%	Additions of silicon to non-ferrous metals, particularly aluminum and copper, to improve physical properties.
Purified Grade	Silicon....99.70 to 99.90% Iron.........005 to .015%	For applications in non-ferrous industry requiring silicon of high purity.
Low-Calcium Grade	Silicon..........min. 97% Iron.............max. 1% Calcium.......max. 0.10%	For the production of high-silicon aluminum alloys where calcium is detrimental.
Low-Aluminum Grade	Silicon..........min. 98% Iron.............max. 1% Aluminum.....max. 0.10%	For the production of silicon-copper alloys where aluminum is detrimental.
"SMZ" Alloy	Silicon.........60 to 65% Manganese...... 5 to 7% Zirconium....... 5 to 7%	Particularly strong graphitizing inoculant used in making ladle additions to cast iron.
Special Graphitizer	Ferrosilicon Compound	Acts as both deoxidizer and graphitizer in cast iron. Useful in controlling chilling tendencies.
Magnesium-Ferrosilicon	Silicon.......approx. 46% Magnesium..approx. 8.5%	For ladle addition to cast iron to obtain special properties.
Barium-Silicon	Barium.........40 to 50% Silicon.........45 to 55%	For deoxidation of non-ferrous alloys.
"EM" Silicon Briquets (Cylindrical Shape)		
Large Size	Silicon..............2 lb. Total Weight.........5 lb.	For adding silicon to cast iron in the cupola.
Small Size	Silicon..............1 lb. Total Weight........2½ lb.	

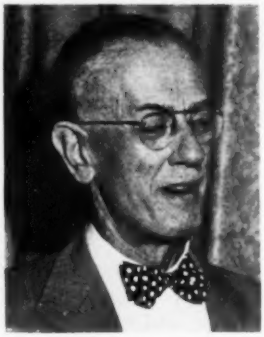
"Electromet," "EM," "Silcaz," "SM," and "SMZ," are trade-marks of Union Carbide and Carbon Corporation.

PRODUCT*	NOMINAL COMPOSITION	USES
TITANIUM ALLOYS		
Ferrotitanium	Titanium......27 to 32% Carbon.......max. 0.10%	For adding titanium to stabilized austenitic chromium-nickel stainless steels and to high-temperature metals.
Silicon-Titanium	Titanium.......40 to 50% Silicon.........45 to 50% Iron.............max. 3%	For additions of titanium to steels or non-ferrous alloys.
Manganese-Nickel-Titanium	Titanium.......43 to 48% Nickel.......approx. 25% Manganese......max. 8% Aluminum......max. 18% Iron............max. 5% Silicon........approx. 2% Carbon........max. 0.15%	Deoxidization of nickel alloys.
TUNGSTEN ALLOYS		
Ferrotungsten	Conforming to A.S.T.M. Spec. A 144-39	For production of tool and die steels; also high-temperature alloys.
Tungsten Metal Powder Melting Grade	Tungsten.....min. 98.80% Total Carbon..max. 0.25%	Production of tungsten steels and cast tungsten carbide.
VANADIUM ALLOYS		
Ferrovanadium	Vanadium......50 to 55% Carbon....max. 0.20, 0.50, or 3.00% Silicon....max. 1.50, 2.00, or 8%	Production of tool and engineering steels, high-strength structural steels, non-aging rimming steels, and wear-resistant irons.
Vanadium Oxide Fused	V_2O_5...........86 to 89% Na_2O........approx. 10% CaO..........approx. 2%	For addition of vanadium to steel and for manufacturing catalysts.
Sodium Polyvanadate (Red Cake)	V_2O_5.........approx. 85% Na_2O.........approx. 9% CaO..........approx. 2% H_2O.........approx. 2.5%	For manufacture of vanadium compounds, including vanadium catalysts.
High-Purity Ammonium Metavanadate	V_2O_5......approx. 99.50% NH_4VO_3.........min. 99%	
ZIRCONIUM ALLOYS		
12 to 15% Zirconium Alloy	Zirconium......12 to 15% Silicon.........39 to 43% Carbon........max. 0.20%	This zirconium alloy is a powerful deoxidizer. It also increases depth of hardening.
35 to 40% Zirconium Alloy	Zirconium......35 to 40% Silicon.........47 to 52% Carbon.......max. 0.50%	Deoxidizer for fine grades of alloy steels. Used for adding larger amounts of zirconium.
Nickel-Zirconium	Zirconium......25 to 30% Nickel..........40 to 50% Aluminum....approx. 15% Silicon.........max. 10% Iron............max. 5%	Effective for deoxidizing and degasifying nickel and its alloys.

Personal Mention

Truman S. Fuller

Don M. McCutcheon



Nelson E. Cook

TRUMAN S. FULLER ⊕, the new president of the American Society for Testing Materials, joined that society and the American Society for Metals at about the same time, in the late 1920's. He has worked for the General Electric Co. since his graduation (B.S. in chemistry) from Syracuse University in 1911, practically all of that time serving as metallurgist in the research laboratory at Schenectady. Since 1945 he has been engineer in charge of the works laboratory. During his 14-year chairmanship of A.S.T.M.'s Committee B-3 on Corrosion, extensive atmospheric tests were conducted. With General Electric his attention was early directed toward the endurance of metals in moist air and steam. Properties of metals at high temperature and the embrittlement of copper also engaged his attention; as one of the original members of the G. E. "Creep Committee" he laid the foundation of what is now called creep-rupture testing, but the work at Schenectady has been extraordinarily diverse, ranging from cemented carbides to die castings to copper to turbine alloys. As to his personal characteristics, one of his associates says "the most outstanding are his honesty and frankness. You know where he stands and why. He backs his men; he plugs for them; they want to work for 'Doc' Fuller. He is by no means stuffy, he is always ready to hear a good story, and try to tell a better one." What better could you say?

DON M. MCCUTCHEON ⊕, a metallurgical engineer who is also a leader in the field of the industrial application of applied physics, has recently been named manager of the physics department of Ford Motor Co.'s new scientific laboratory where research activities in the fields of thermodynamics, physical properties and radiation will be under his direction. Mr. McCutcheon joined Ford in 1935 and has directed the activities of the applied physics unit of the Ford Manufacturing Research Department since 1945. Among the projects he has directed was the development of a successful isotope gage for determining automatically the height of liquid metal in iron foundry cupolas, and an isotope gage which automatically records sheet steel thickness in the cold rolling mill. He received his B.S. degree in chemical engineering from the University of Michigan in 1931, and his M.S. degree in metallurgical engineering two years later. He has served as lecturer for the University's extension course on X-ray diffraction and radiographic inspection, and is a member of the physics advisory committee of Wayne University. Mr. McCutcheon has addressed many technical groups throughout the country and he has published a great number of papers on the subjects of radiography, X-ray diffraction, nondestructive testing and the industrial uses of radioisotopes.

NELSON E. COOK ⊕, general superintendent of galvanizing at the Wheeling Steel Corp., Wheeling, W. Va., was recently presented with the 1950 Annual Award of the Galvanizers' Committee of the American Zinc Institute in recognition of his "distinguished service in the field of galvanizing". Mr. Cook, one of the organizers of the Galvanizers' Committee, has served as chairman for five terms and is at present a member of its governing board. He represents the fourth generation of galvanizers in his family, and has been associated with the Wheeling Steel Corp. for 29 years, having succeeded his father, the late William J. Cook, who had been in charge for over half a century, as head of all galvanizing operations for Wheeling. Mr. Cook is a graduate of Cornell University where he received his M.S. degree in chemistry, and he is the holder of numerous patents for galvanizing processes. He has been a member of the American Society for Metals for over 25 years.

James H. Keeler ⊕ has joined the General Electric Research Laboratory, Schenectady, N. Y., as a research associate.

William L. Frankhouser ⊕ has been employed as a metallurgist for Kuhns Brothers Co., Dayton, Ohio.

Raymond E. Tate ⊕ has joined the Los Alamos Scientific Laboratory as a staff member in the chemistry and metallurgy division. He was formerly with Fairchild Engine and Airplane Corp., Hagerstown, Md.

Personals

Robert A. Mayer is now civilian chief of the aluminum unit in the Aircraft Production Resources Agency, Wright-Patterson Air Force Base, Dayton, Ohio.

Clyde R. Tipton, Jr., formerly physical metallurgist with the University of California's Los Alamos Scientific Laboratory, has joined the staff of Battelle Memorial Institute, Columbus, Ohio.

Edward B. Westall has returned to the United States after three years in Brazil as chief engineer with Borden Co.'s affiliated company, Alba S/A, and has been assigned as chief project engineer on the new Chemical Division of Borden's plant being built at Demopolis, Ala.

Herbert L. Kee has been employed by Wright Aeronautical Corp., Woodridge, N. J., as a metallurgist. He received his M.S. degree from Pennsylvania State College in June.

Officers of the newly formed National Association of Aluminum Distributors, Cleveland, include **Harry L. Edgcomb, Jr.,** president, **T. E. Conklin**, vice-president, and **Ralph W. Shaw, Jr.,** treasurer. The association was founded to deal with the problems arising out of the phenomenally rapid growth of the aluminum industry which started just after World War II and has been continuing without signs of a let-up since that time.

W. W. Sieg, president of the Titan Metal Manufacturing Co., Bellefonte, Pa., has been appointed a member of the Brass Mill Industry Advisory Committee of the National Production Authority, Washington, D. C.

N. W. Bass, formerly assistant vice-president of the Brush Beryllium Co., Cleveland, has been promoted to vice-president of the company.

V. H. Ferguson has been elected president of the newly formed Ferguson Equipment Corp., Pittsburgh. He was formerly with the Loftus Engineering Corp., Pittsburgh.

William W. Wellborn has been appointed research engineer of the carbide research and development department of the Firth Sterling Steel & Carbide Corp., Pittsburgh.

Glenn Coley, sales department, Detroit Edison Co., has been presented with the company's Alex Dow Award in recognition of his help in the development of a method to humidify the combustion air used in stoker-fired boilers at the company's power plants.

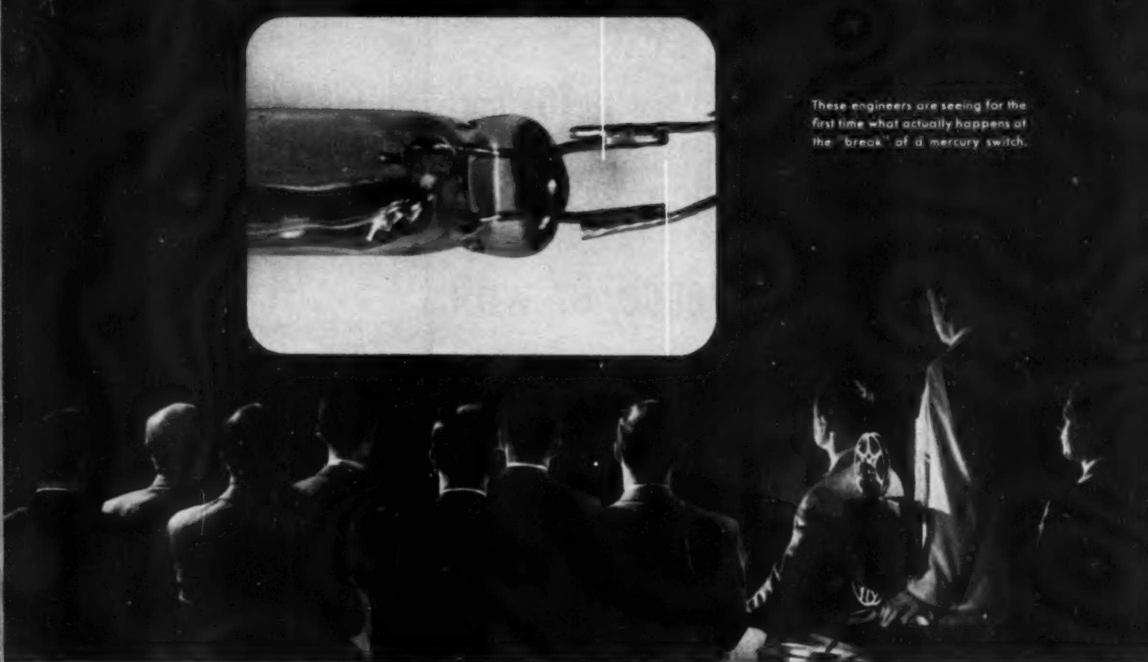
H. J. Butterill has recently been appointed chief metallurgist and chief inspector for the Arvica (Quebec) Works of the Aluminum Co. of Canada, Ltd.

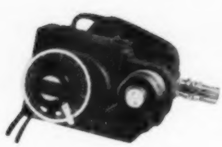
John H. Alden, who has been with the Aluminum Co. of America for the past 28 years, has recently been appointed chief metallurgist of the Fabricating Division, Pittsburgh.

Harry K. Herschman has been transferred from the National Bureau of Standards to the National Production Authority, Metallurgical and Conservation Branch of the Iron and Steel Division.

Vincent Lysaght has been appointed sales manager of the Helicoid Gage Division, American Chain & Cable Co., Inc., Bridgeport, Conn.

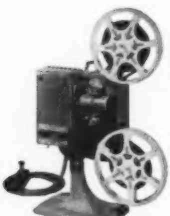
Now... High Speed Movies of Mechanical Action and Oscillograph Traces Combined on One Film!



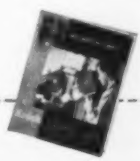


The Kodak High Speed Camera can now be supplied with a special feature which permits the recording of cathode-ray oscillograph traces through the back of the film. This makes possible high speed motion pictures of mechanical action with its electrical aspects simultaneously superimposed *on the same 16mm film.* When projected at normal speed, you get a complete picture of combined mechanical and electrical action slowed down as much as 200 times.

This basic improvement has countless new applications for solving design, production, and product performance problems through high speed movies, particularly those involving electrical equipment. Since an argon lamp times the film travel, extremely accurate analysis is possible. This unique tool may be the answer for which you have been looking. Further information and a copy of the booklet "Magnifying Time" will gladly be sent on request.



The Kodascope Sixteen-10R Projector . . . To show your high speed movies so that you can study the critical phases of action, this moderately priced projector is equipped with a remote-control push button for reversing film direction over and over again. Its 2-inch *f*/1.6 lens and 750-watt lamp assure bright screen illumination, sharp from edge to edge. Important details stand out clearly, even if exposure conditions have not been optimum.



EASTMAN KODAK COMPANY, Industrial Photographic Division, Rochester 4, N. Y.

High Speed Movies

. . . a function of photography

Kodak
TRADE-MARK

Personals

M. R. Gallo ⊕, formerly with Clark Bros. Co., Inc., Olean, N. Y., is now representing the Buflovak Equipment Division of Blaw-Knox Co., Buffalo, N. Y.

Jay O. Mack ⊕ has been transferred from his position as supervising technologist, metallography and silicon steels, Research and Development Laboratory, United States Steel Co., Pittsburgh, to that of chief control and development metallurgist in the company's Fairless Works, Morrisville, Pa.

A. S. Cogan ⊕ has been appointed to the ammunition department of the Research and Development Division, Olin Industries, Inc., New York. He was formerly general supervisor of metallurgical and chemical laboratories in the New Departure Division, General Motors Corp., Bristol, Conn.

Phillip R. Kalischer ⊕, metallurgist and development engineer, has been appointed associate editor of *Precision Metal Molding* (formerly *Die Castings*) magazine, Cleveland. He was formerly chief engineer in charge of laboratory research on the production of ultra high purity beryllium with Brush Beryllium Co., Cleveland, and with Firestone Tire and Rubber Co., Akron, Ohio, on gun and projectile design and research.

James R. Coxey ⊕, formerly assistant professor of metallurgy at Pennsylvania State College, has taken a position as chief of the metals section in the office of the Deputy Chief of Staff, Materiel Headquarters, United States Air Force, Washington, D. C.

Robert Zanoni ⊕ has been employed on the training program for engineers in the Components Laboratory Division, Detroit Arsenal, Center Line, Mich.

Henry F. Keller, Jr., ⊕ has been employed as a metallurgist by American Radiator and Standard Sanitary Corp.'s Plumbing Research Division, Louisville, Ky.

Frederick Jackson ⊕, formerly metallurgist with the Riverside Metal Co., Riverside, N. J., is now a metallurgist with Kaiser Aluminum and Chemical Corp., Newark, Ohio. He is assigned to the wire department.

Personals

Joseph B. Darby, Jr., a June graduate of Virginia Polytechnic Institute, has been employed as a metallurgical engineer in the process and product development department of the National Carbon Co., Niagara Falls, N. Y.

Joseph F. Boyce has been appointed eastern sales manager, with offices in Newark, N. J., for the Cyclone Fence Division, American Steel and Wire Co.

Douglas H. Polonis has been employed by the Steel Co. of Canada, Hamilton, Ont., and is taking the company's engineering training course. He graduated from the University of British Columbia in May.

John A. Milko, formerly with Battelle Memorial Institute, Columbus, Ohio, has been employed as a metallurgist, and **Eugene E. Hoffman**, from Sibley Machine and Foundry Corp., South Bend, Ind., and **William C. Hagel**, a recent Cornell graduate, have been employed as junior metallurgists by the Union Carbide and Carbon Corp., Oak Ridge National Laboratory, Oak Ridge, Tenn.

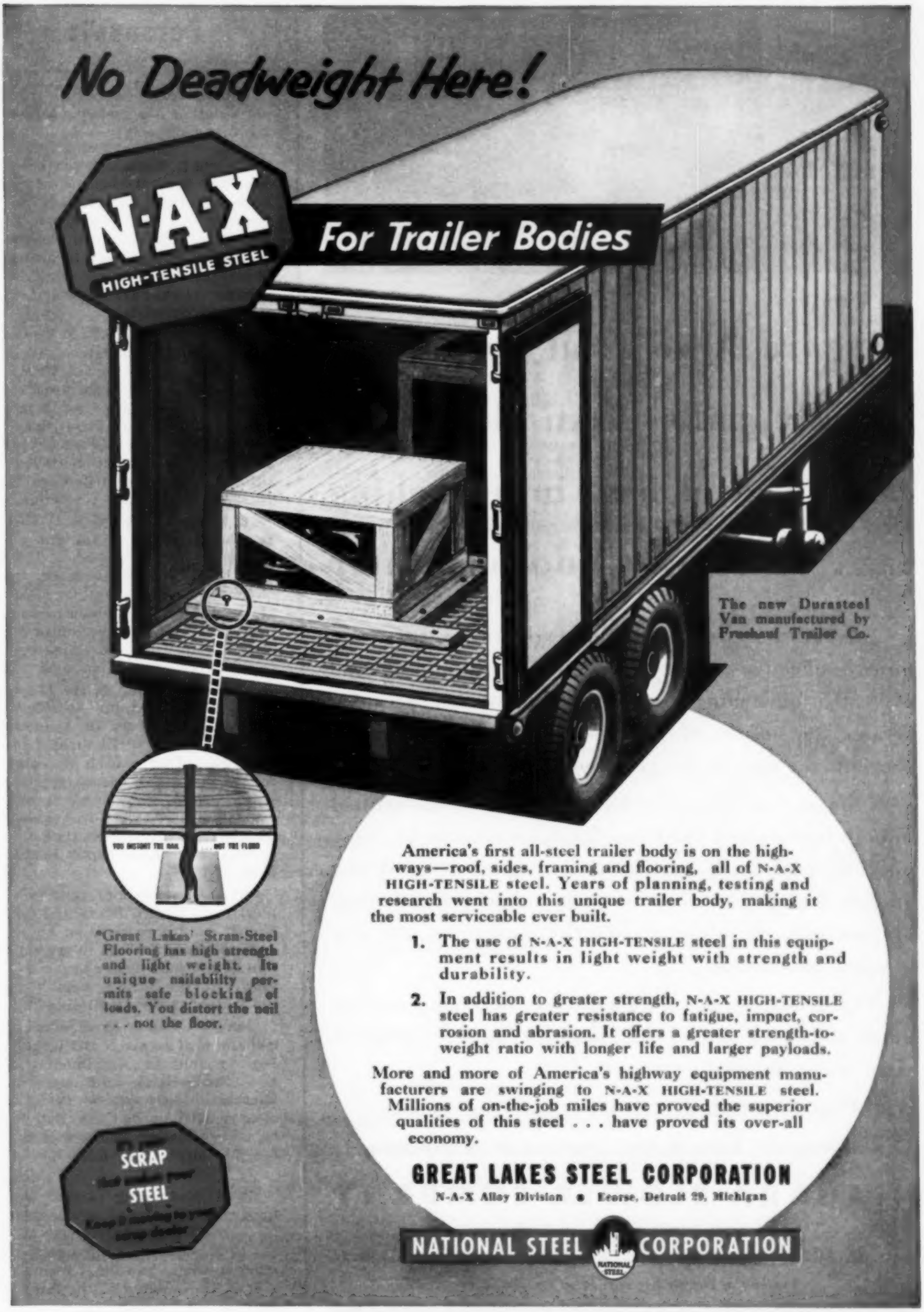
William K. Rogers, a March graduate of the Michigan College of Mining and Technology, has been employed in the metallurgical laboratory, Barber-Colman Co., Rockford, Ill.

D. A. Stewart has retired from his position as a director of Serck Tubes Ltd., Birmingham, England, and is taking up residence in Scotland.

James D. White, Jr., and **Ralph A. Williams** have been appointed president and general manager, and assistant general manager, respectively, of Darwin & Milner, Inc., Cleveland.

Roy E. Swift has joined the faculty of the department of mining and metallurgical engineering, University of Kentucky, Lexington. Dr. Swift was formerly on the staff of the Mackay School of Mines of the University of Nevada, Reno.

Edwin J. Soxman has been employed as a research associate on an Air Force project, Alfred University, Alfred, N. Y., since he graduated from Missouri School of Mines in May.



No Deadweight Here!
N·A·X
HIGH-TENSILE STEEL
For Trailer Bodies
The new Durasteel Van manufactured by Fruehauf Trailer Co.
*Great Lakes' Stran-Steel Flooring has high strength and light weight. Its unique nailability permits safe blocking of loads. You distort the nail . . . not the floor.
America's first all-steel trailer body is on the highways—roof, sides, framing and flooring, all of N-A-X HIGH-TENSILE steel. Years of planning, testing and research went into this unique trailer body, making it the most serviceable ever built.
1. The use of N-A-X HIGH-TENSILE steel in this equipment results in light weight with strength and durability.
2. In addition to greater strength, N-A-X HIGH-TENSILE steel has greater resistance to fatigue, impact, corrosion and abrasion. It offers a greater strength-to-weight ratio with longer life and larger payloads.
More and more of America's highway equipment manufacturers are swinging to N-A-X HIGH-TENSILE steel. Millions of on-the-job miles have proved the superior qualities of this steel . . . have proved its over-all economy.
GREAT LAKES STEEL CORPORATION
N-A-X Alloy Division • Ecorse, Detroit 29, Michigan
SCRAP
STEEL
NATIONAL STEEL CORPORATION

Personals

The American Society for Testing Materials has made the following announcements:

Harold H. Morgan ⊕, vice-president and general manager of the Robert W. Hunt Co., Chicago, was awarded A.S.T.M.'s Certificate of Honorary Membership in recognition of his notable work in various phases of the Society's work involving standardization and research in materials.

D. S. Clark ⊕ and **P. E. Duwez** ⊕, California Institute of Technology, have received A.S.T.M.'s Charles B. Dudley Medal for their paper, "The Influence of Strain Rate on Some Tensile Properties of Steel". This medal is presented for a paper of outstanding merit constituting original contributions on engineering materials research.

R. L. Templin ⊕ and **W. C. Aber** ⊕, Aluminum Co. of America, received A.S.T.M.'s Richard L. Templin Award for their paper, "A Method for Making Tension Tests of Metals Using a Miniature Specimen". This award is presented for a significant paper describing new testing methods and apparatus.

C. T. Evans, Jr., ⊕, the Elliott Co., was awarded the Sam Tour Award for his paper, "Oil Ash Corrosion of Metals at Elevated Temperatures". This award is presented for the purpose of encouraging research on the improvements and evaluation of corrosion testing methods and to stimulate the preparation of technical papers in this field.

Hyman Bornstein ⊕, chief technical consultant, Deere and Co., Moline, Ill., has received an Award of Merit from A.S.T.M. in recognition of his long-time, constructive service to the Society, notably in the fields of cast and malleable iron.

John W. Bolton ⊕, director of metallurgical research and testing, Lunkenheimer Co., Cincinnati, and **F. P. Zimmerli** ⊕, chief engineer, Barnes-Gibson-Raymond Division of Associated Spring Corp., Detroit, have been elected members of the board of directors by A.S.T.M.

R. H. Noderer ⊕ recently retired after 47 years of service with U. S. Steel Co. subsidiaries. He has been employed for the past 41 years at what is now the Johnstown Works, U. S. Steel Co., the last 15 years as chief metallurgist.

Personals

T. R. Graham ⊕ has been transferred from his position as chief of the Metallurgy Branch, Rolla, Mo., to chief of the Physical Metallurgy Branch, College Park, Md., by the Bureau of Mines.

Charles B. Cobun ⊕, associated with the United States Steel Co. for many years, has joined the Chicago district sales office of Heppenstall Co., Pittsburgh.

Carl M. Loeb, Jr., ⊕, president of Climax Molybdenum Co., New York, has become a member of the Board of Sponsors of the American Baseball Academy, New York, a new organization formed to combat juvenile delinquency in metropolitan areas.

Earl Brodhag ⊕ has been appointed development engineer for the American Wheelabrator and Equipment Corp., Mishawaka, Ind. He was formerly a manufacturer's agent for Vapor Blast Manufacturing Co., Milwaukee.

Donald L. Swanson ⊕ graduated from Iowa State College in June and is now working at Experiment, Inc., Richmond, Va., as a research engineer.

John P. Nielson ⊕, associate professor of metal science, New York University, has been appointed to direct the Department of the Army contract awarded the University covering research projects on titanium.

Howard R. Palmer ⊕ and **William P. Roe, Jr.**, ⊕, have been employed by the National Lead Co., Titanium Division, South Amboy, N. J., as metallurgists.

William A. Cheesebrough ⊕ has been a trainee at Inland Steel Co., East Chicago, Ind., since his graduation from Carnegie Institute of Technology in June.

Michael F. Stavich ⊕, a recent graduate of Carnegie Institute of Technology, is now a staff member of the fusion joining department of the Metallurgical Research Division, Kaiser Aluminum and Chemical Corp., Spokane, Wash.

Arthur T. Morgan ⊕ has been employed as a metallurgical engineer, training at Inland Steel Co., Indiana Harbor, Ind., since his graduation from Purdue University.

PUSH-BUTTON CLEANING!

MECHANIZED LOADING!

SIMPLIFIED UNLOADING

Here's How Pangborn ROTOBLAST* Barrels SPEED DEFENSE PRODUCTION!

SPEED is essential to defense production . . . and in case after case, Pangborn ROTOBLAST Barrels have proved they can clean castings up to 24 times faster than conventional equipment. Even loading is fast! With Pangborn automatic loading equipment, any size ROTOBLAST Barrel (from $3\frac{1}{2}$ to 28 cubic feet) can be loaded *in one minute or less!*

What's more, Pangborn ROTOBLAST Barrels assure high-quality cleaning. The exclusive "rocking" action of the Barrel exposes all surfaces to the blast stream . . . makes sure pockets of intricate pieces are completely cleaned. And ROTOBLAST Barrels cost less to operate. Horsepower requirements average 87% less, smaller crews are needed and automatic abrasive recovery assures maximum economy.

FOR FASTER BLAST CLEANING install Pangborn ROTOBLAST Barrels in your cleaning room. Bulletin 213 gives you full details, specifications and actual performance as reported by users. Write today to: PANGBORN CORP., 1800 Pangborn Blvd., Hagerstown, Md.

Look to Pangborn for the latest developments in Blast Cleaning and Dust Control equipment.

These action photographs prove Pangborn ROTOBLAST Barrels are easy to operate. This 14' ROTOBLAST Barrel is shown in use at the Frick Company. It speeds cleaning by replacing four old-style machines and a secondary pickling operation. And with this machine two men can clean half the entire foundry's output—at an annual saving of $2540.00 on labor!

ROTOBLAST . . .

SAVES LABOR with push-button operation
SAVES SPACE because machines are compact
SAVES TIME by cleaning more loads per day
SAVES POWER since no compressor is needed
SAVES TOOLS because all scale is removed

FOUNDRY EQUIPMENT MANUFACTURERS ASSOCIATION INC. MEMBER FEMA

Pangborn

BLAST CLEANS CHEAPER

with the right equipment for every job

*Trademark of the Pangborn Corporation

Personals

Earl J. Gossett ⊕, founder and president of Bell & Gossett Co., Morton Grove, Ill., has been elected to the board of directors of the Oil Heat Institute of America.

M. Brezin ⊕ has been promoted from assistant chief metallurgist to chief metallurgist of the Homestead (Pa.) District Works, United States Steel Co.

Richard J. Haffeman ⊕ has been employed as a metallurgical engineer trainee at Deere & Co., Moline, Ill., since his graduation from University of Wisconsin in June.

John W. Yeasley ⊕ has been employed as an engineering trainee by the Aluminum Co. of America, Vancouver Works, since his graduation from the University of Washington in February.

R. M. Dyke ⊕, formerly active in technical-vocational education in British Columbia and Alberta, has joined the editorial staff of *Machine Production* magazine, Toronto, Ont.

Paul J. Hagelston ⊕, formerly head of the materials laboratory, Carbide and Carbon Chemicals Co., Oak Ridge, Tenn., is now with the Production Branch, Technical and Production Division, Savannah River Operations Office, U.S. Atomic Energy Commission, Aiken, S. C.

J. Jarms ⊕ has recently joined the C. B. Herrick Co., Cleveland, as assistant sales manager. He was formerly a welding engineer in the jet division, Thompson Products, Inc., Cleveland.

R. K. Rarick ⊕, formerly metallurgist and welding engineer in the Bendix Products Division, Bendix Aviation Corp., South Bend, Ind., has been promoted to superintendent of special processes in the company's newly established Hamilton Division, Hamilton, Ohio.

Ernest G. Kendall ⊕ has accepted a position as metallurgical engineer for Titanium Metals Corp. of America, Henderson, Nev.

Howard Heineke ⊕ has been employed in the general laboratories of the Reduction Department, Great Falls, Mont., of Anaconda Copper Mining Co., since his graduation from the University of Kentucky in June.

Personals

Myron P. Davis has retired from his position as chief chemist and metallurgist, Otis Elevator Co., Yonkers, N. Y.

James T. Kemp has transferred from his position as metallurgical engineer for American Brass Co., San Francisco, to the Defense Minerals Administration, U. S. Bureau of Mines, Washington, D. C.

James T. MacKenzie, technical director of American Cast Iron Pipe Co., Birmingham, Ala., is the 1951 winner of the Herty Medal, sponsored by the Chemistry Club of the Georgia State College for Women and administered by the American Chemical Society, for his research in metals.

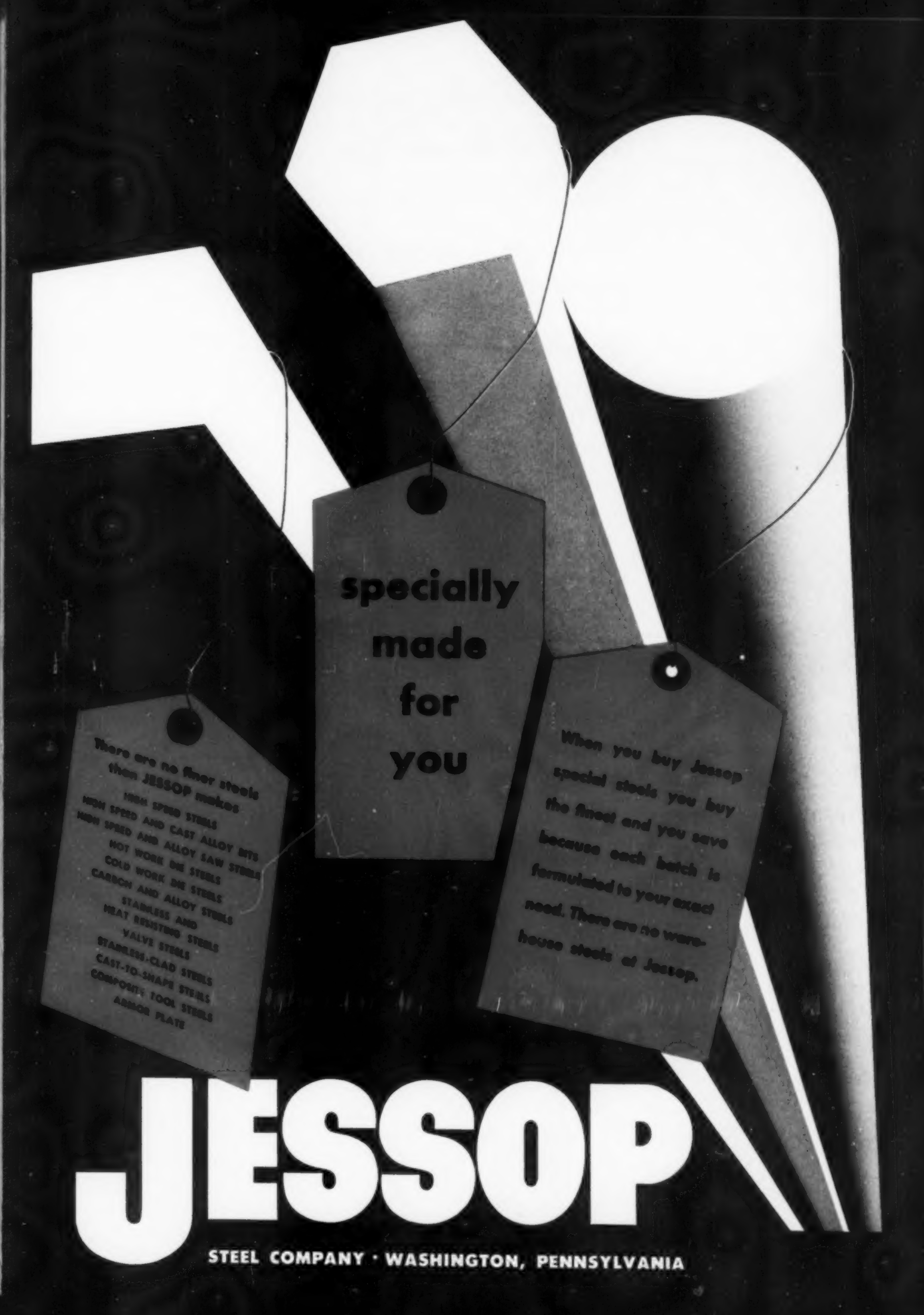
Wayne R. Rawlings has accepted a position as metallurgist in the metallurgical laboratory of Bell and Howell Co., Chicago.

Recent appointments to the staff of the Metallurgical Division of the Oak Ridge National Laboratory, operated by Carbide and Carbon Chemicals Co., Oak Ridge, Tenn., include **Thomas K. Roche** as metallurgical assistant, and **Joseph F. Delaney** as junior metallurgist. Both men are recent graduates of the University of Notre Dame, South Bend, Ind.

Oliver Smalley, president of the Meehanite Metal Corp., New Rochelle, N. Y., has been elected an honorary life member of the Institute of British Foundrymen, London, in recognition of his services to the foundry industry over a long period of years.

I. Melville Stein, formerly associate director of research for Leeds & Northrup Co., Philadelphia, has been elected executive vice-president to the company's newly created post.

George T. Jones has been promoted to the position of metallurgical engineer, and **R. W. Steigerwalt** has been appointed metallurgical adviser of United States Steel Co.'s railroad materials and forgings division, Pittsburgh. **Carl W. Tuttle** succeeds Mr. Jones in his position as assistant metallurgical engineer, and **James R. Hamilton** has been appointed senior service metallurgist, railroad materials and forgings division, in the company's Chicago office.


specially made for you
There are no finer steels than JESSOP makes
HIGH SPEED STEELS
HIGH SPEED AND CAST ALLOY BITS
HIGH SPEED AND ALLOY SAW STEELS
HOT WORK DIE STEELS
COLD WORK DIE STEELS
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VALVE STEELS
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When you buy Jessop special steels you buy the finest and you save because each batch is formulated to your exact need. There are no warehouse steels at Jessop.
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★ **ARCALOY** for stainless steel

★ **ARMOR-ARC** for armor welding

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★ **WELD-ARC** for low hydrogen electrodes

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★ **TOOL-ARC** for tool steel

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NAMES TO REMEMBER IN ARC WELDING

100% of all *Alloy Rods* production is still being sold through our fine Distributor organization. We are shipping more alloy arc welding electrodes than ever before . . . and while our Distributors may temporarily be out of stock on certain types, we urge you to keep in touch with them on your requirements. After all, *quality* is always worth waiting for.

ALLOY RODS COMPANY

No Finer Electrodes Made . . . Anywhere

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★ *See your nearest Alloy Rods Distributor*

AR-2

METAL PROGRESS

BULLETIN BOARD

THE BUYERS' GUIDE FOR METALS ENGINEERS

This year's METAL SHOW

IS EVERYBODY'S BUSINESS

Nation-wide . . . world-wide . . . is the impact of the 1951 Metal Show . . . for never before have so many humans looked to the metal industry for the skill . . . the ingenuity . . . the resourcefulness that must be marshaled behind the free world's urgent need for the weapons of defense against a common enemy. That's why this finest and most important Metal Show looms as the vital and timely thing it is . . . a great industry's stirring answer to a world-wide challenge. Be there . . . all the men who make the metal industry what it is will be there, too.

DETROIT
MICH.
Oct. 15-19

NATIONAL METAL EXPOSITION

NATIONAL METAL CONGRESS

WORLD METALLURGICAL CONGRESS

MANHATTAN

Abrasive Wheels — Cut-off Wheels
Finishing Wheels—Diamond Wheels

Custom-made for your specific material removal problems

Foundry Snagging—Billet Surfacing—Centerless Grinding
Cutting and Surfacing concrete, granite, and marble
"Moldiscs" for rotary sanders
Grinding and Finishing stainless steel welds
Bearing Race Grinding and Finishing
Finishing Tools and Cutlery
Cutting-off—Wet or Dry Bars, Tubing, Structurals, etc. Foundry Cutting —standard and reinforced wheels
Grinding Carbide Tipped Tools

Write to Abrasive Wheel Department

Raybestos-Manhattan, Inc.
MANHATTAN RUBBER DIVISION
92 TOWNSEND ST. • PASSAIC, N. J.

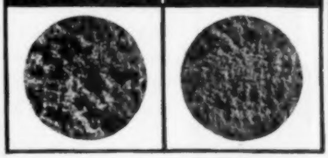
LIST NO. 1 ON INFO-COUPON PAGE 143

Notice

This Bulletin Board section of METAL PROGRESS brings you advertisements grouped according to products and services. Each ad carries a reference number at the bottom. Simply list this number on the coupon, page 143, and your requests for literature or other information will receive prompt attention.

Which is better for YOUR product?

NON-GRAN SAND CASTING	NON-GRAN CENTRIFUGAL



• *Request Booklet!*

American Non-Gran Bronze Co., Berwyn, Pennsylvania

NON-GRAN

LIST NO. 3 ON INFO-COUPON PAGE 143

WANTED

MORE IRON AND STEEL SCRAP . . . OF ALL KINDS!

Steel mills and foundries need more scrap—all sorts of *idle* iron —from all types of plants.

Search *your* plant for this idle metal . . . work with your local scrap dealer to increase supplies of badly-needed iron and steel scrap.

The Structure of Cast Iron

By Alfred Boyles
U. S. Pipe & Foundry Co.

A book that tells what cast iron really is and gives the facts basic to an understanding of applications.

154 pages . . 94 illus. . . $3.50

American Society for Metals
7301 Euclid Cleveland

IMPOSSIBLE

NOW POSSIBLE
95-LB. PRECISION CASTINGS

Hastelloy, 316, 347, 410, 431 s.s. 4130, 4120, 1020, Copper, Aluminum

AN EXPERIENCED ENGINEERING STAFF AVAILABLE TO HELP WITH YOUR DESIGN PROBLEMS

INQUIRIES INVITED . . .
BROCHURE ON REQUEST

ALLOY PRECISION CASTING CO.
E. 45 ST. & HAMILTON • CLEVELAND, O.

LIST NO. 6 ON INFO-COUPON PAGE 143

LEAKE
Creative
METAL STAMPINGS

Any Size-Shape-Thickness-Analysis

Literature on request

THE LEAKE STAMPING CO.
MONROE, MICHIGAN

LIST NO. 68 ON INFO-COUPON BELOW

WELDER'S CRAYON

Korn's special crayons, developed specifically for welding operators, layout men and other metal workers, will produce permanent markings on all types of hot, cold, wet or dry metals. Mark your cutting and welding lines for easier and more accurate results.

Wm. KORN, INC.
260 WEST ST. • DEPT. M. P.
NEW YORK 13, NEW YORK

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WAGNER
ELECTRODE HOLDERS

WELD BETTER WITH

• WAGNER GROUND CLAMPS

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• WAGNER "SWEDG-ON" ITEMS

Sold Only Thru Welding Supply Houses

WAGNER MFG. CO.
350 W. 1st SOUTH ST.
JACKSON, MISSOURI

Weld with Wagner

LIST NO. 69 ON INFO-COUPON BELOW

A CABLE SPLICED IN 10 SECONDS!

ERICO PRODUCTS, INC.
Complete Arc Welding Accessories
2070 E. 61st Place, Cleveland 3, Ohio
Write for Caddy Catalog

LIST NO. 71 ON INFO-COUPON BELOW

READERS' INFO-COUPON SERVICE, METAL PROGRESS
7301 Euclid Avenue, Cleveland 3, Ohio

Please send further information, as checked at the right, on the advertisements in the Bulletin Board with numbers I have listed below—

(Please check)

(Bulletin Board Item Number)	Send Catalog or Engineering Data	Send Price Info	Nearest Source of Supply
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	☐	☐	☐
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	☐	☐	☐
	☐	☐	☐

Your Name ______ **Title** ______

Company ______

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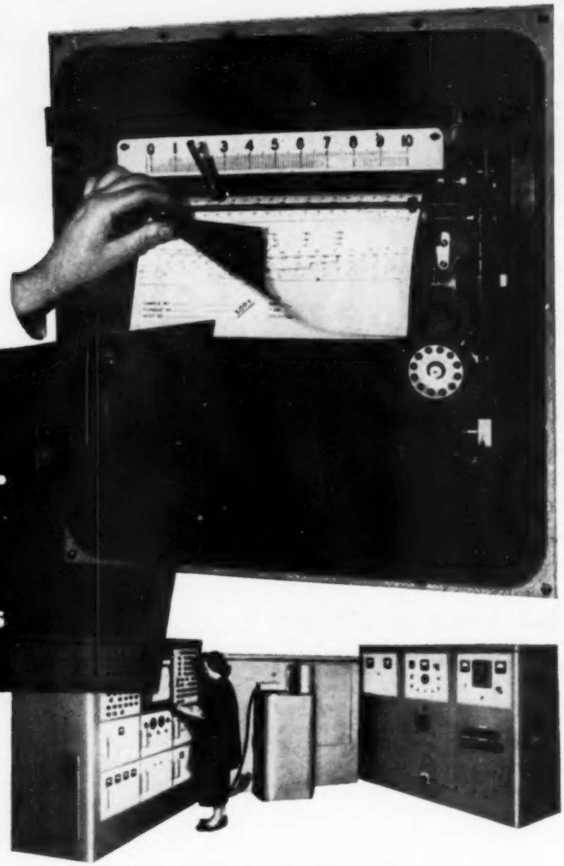
See demonstration
Booth No. G121—Bldg. G.
National Metal Exposition



IN 2 MINUTES...
metal analyses in multiple copies

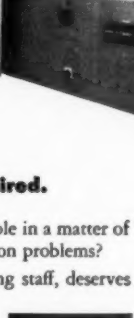
Only ARL Production Control Quantometer* gives you direct reading, pen-and-ink records of quantitative spectrochemical analyses with extra copies, as desired.

Would quick, accurate chemical analyses of metals or other inorganic materials, available in a matter of minutes in the form of multiple-copy graphic records, help solve your testing and production problems?

If so, the Production Control Quantometer, pioneered and perfected by our engineering staff, deserves your most serious consideration. Unique in its field, this instrument is in daily use throughout the country, helping to speed production of critical materials, improving laboratory controls, and assisting scientific research.

Representing the most advanced type of spectrometer yet developed, and manufactured by the world's largest manufacturer of this kind of equipment, it is extremely efficient, versatile and applicable to a wide variety of needs. As many as 25 chemical elements as selected by the user can be measured on the Production Control Quantometer—up to 20 simultaneously. Individual units are not limited to a single type of analysis, but can be designed to meet the requirements of many major plant problems. Results are comparable to chemical analyses in accuracy.

The complete ARL line also includes 1.5 and 2-meter Spectrographs, Source Units and related accessories.



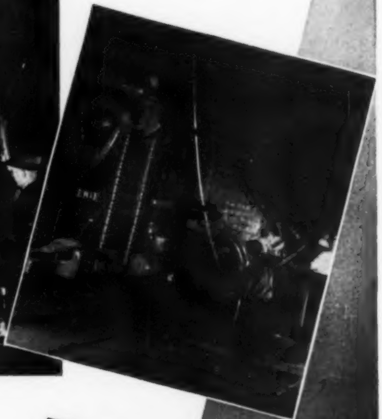
Write for this informational brochure

*Trademark

Applied Research Laboratories
SPECTROCHEMICAL EQUIPMENT
4336 SAN FERNANDO ROAD • GLENDALE 4, CALIFORNIA
NEW YORK • PITTSBURGH • DETROIT • CHICAGO • LOS ANGELES

"DIVERSITY"

ERIE builds the right hammer for the job . . . Here illustrated *in operation* are Erie Steam, Air, Board Drop and Pneumatic Hammers, Erie Single and Double Frame Forging Hammers, and Erie Trimming Presses . . . products of a half century of hammer design and building "know how". Erie engineers will consult with you on your requirements . . . write us before purchasing equipment for producing modern forgings.



All parts on Erie Hammers subject to impact, upper works, frames and anvil are steel.

ERIE

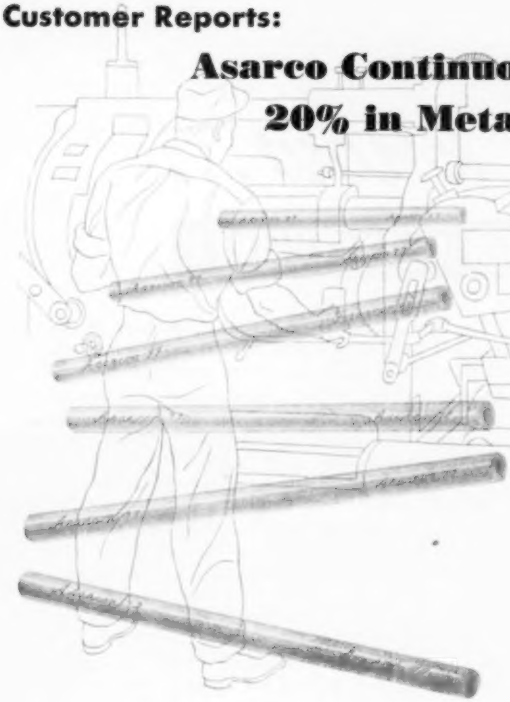
Bulletins giving full details on any or all of these Erie products are available to you for the asking.

ERIE FOUNDRY COMPANY, ERIE, PA.

ERIE BUILDS *Dependable* HAMMERS

Customer Reports:

Asarco Continuous Cast Bronze Saves 20% in Metal Cost, Production Time



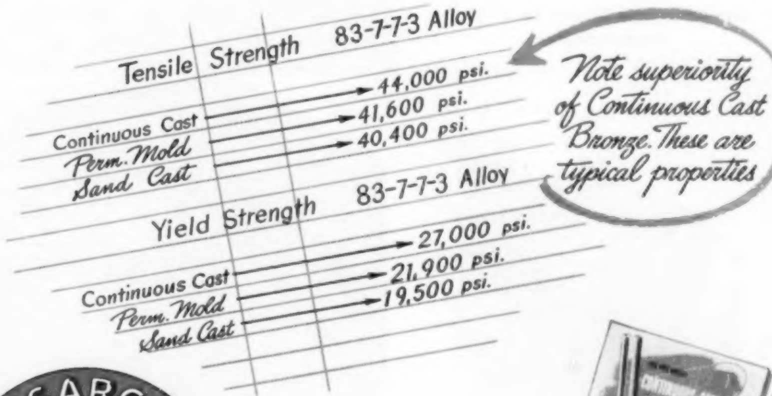
A manufacturer of packaging machinery tells of saving 20% in production time and 20% in material cost when he makes shaft bearings and nuts of Asarco Continuous Cast Bronze.

The patented Asarco casting process guarantees him bronze rod that is free from the hard and soft spots so often found in sand cast bronzes. Stock is exceptionally uniform and free from porosity. Since sand is not used, and dirt and dross are excluded, there can be no surface or internally trapped abrasive to dull tools or discourage high cutting speeds. Rejects are virtually unknown.

Dimensions are held to extremely close limits. For example, tube concentricities are within 1.5% of wall thickness. Dimensional uniformity is assured . . . machining on automatics is standard practice.

Continuous Cast Bronzes can be made to order in a wide variety of alloys . . . in standard lengths of 12′ . . . lengths 5′ to 12′ on request . . . lengths 12′ to 20′ on special arrangement.

216 sizes of standard Asarcon 773 bronze (SAE 660) are stocked in 105″ lengths for convenience at warehouses in all principal cities. Distributors will cut this stock long or short to suit your needs.



ASARCO CONTINUOUS-CAST RODS · TUBES · SHAPES ®

Send for this free catalog on Asarco Continuous Cast Bronzes. It contains physical properties, table of weights, photomicrographs, table of stock shapes and sizes and other data.

West Coast Sales Agent:
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OFFICES: Perth Amboy Plant, Barber, New Jersey
Whiting, Indiana

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ACME'S XN TOGGLE DESIGN IS EXCLUSIVE?

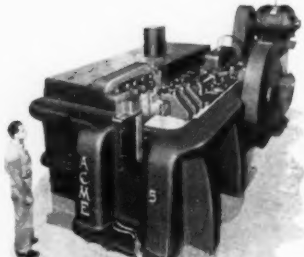
Double Toggle Cluster for 2" and larger machines.

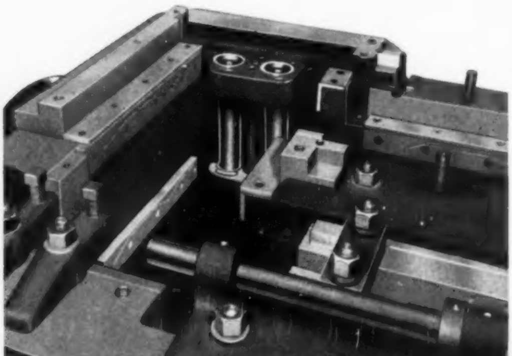
● Among the outstanding features of the Acme XN Forging Machine, none is more important than the Acme Toggle design and construction.

This solid Toggle link construction, exclusive to Acme XN Forging Machines, has large continuous surface areas which reduce pressures per square inch, reflecting lower maintenance cost. Acme design eliminates shoulder wear on pins and bushings common to the hinged or laced type toggles.

The Toggle Links rigidly support the gripping die with a continuous bearing throughout the entire length and height, insuring uniform gripping in all parts of dies and resisting any tendency for the forging dies to breathe—the common cause of excessive flash, swollen and eccentric forgings.

The powerful action of the Acme Toggle Mechanism permits numerous operations, such as squeezing, piercing, shearing, as well as actual forging operations to be performed between the forging dies.





Die Slide Pocket for Double Toggle 2" and larger machines.

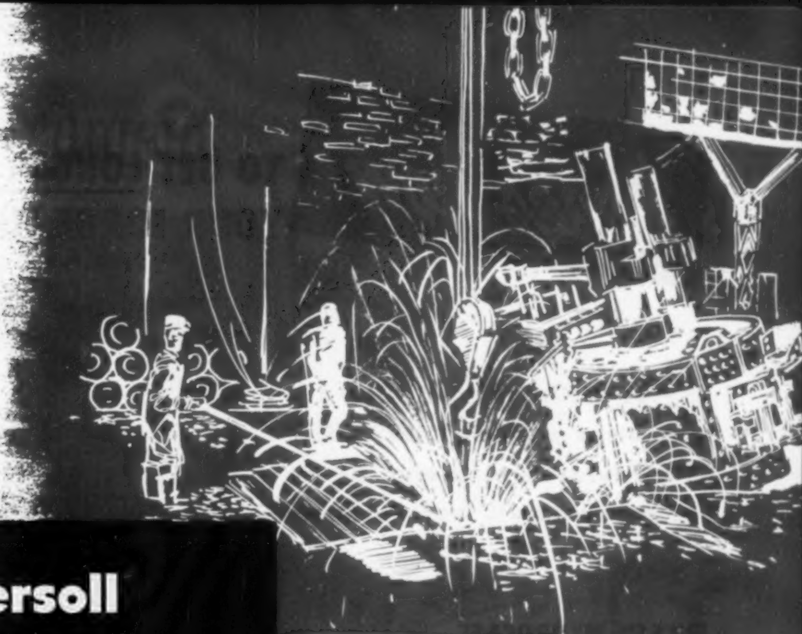
HILL ACME TOOLS FOR INDUSTRY

THE HILL ACME COMPANY

ACME MACHINERY DIVISION • 1207 W. 65th St., Cleveland 2, Ohio

ESTABLISHED 1882

"ACME" FORGING • THREADING • TAPPING MACHINES • ALSO MANUFACTURERS OF "HILL" GRINDING AND POLISHING MACHINES
HYDRAULIC SURFACE GRINDERS • "CANTON" ALLIGATOR SHEARS • PORTABLE FLOOR CRANES • "CLEVELAND" KNIVES • SHEAR BLADES

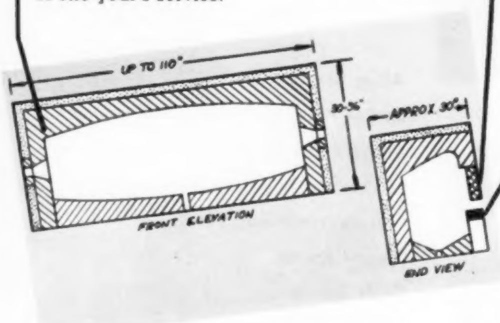


here's how TO GET <u>LONGER LIFE</u> FOR YOUR FORGE FURNACE LININGS

Taylor Sillimanite (TASIL) refractories prolong service life of 50 furnaces operated by an automotive parts manufacturer.

TASIL HYDROCAST—the hydraulic-setting castable refractory for service up to 3000° F.—is used to cast the backwall, end walls, burner openings and roof. Mix Hydrocast with water and pour in place like concrete—your special shapes are in the bag! TASIL Hydrocast main linings in these furnaces are giving a minimum of one year's service.

TASIL TILE are used for the front arch, where resistance to spalling from thermal shock or rapid heating is required. TASIL tile generally last from 2 to 6 months, depending on the severity of the furnace operation. This is 4 to 6 times the life of fireclay tile.



TAYCOR BRICK (90% Al_2O_3) were selected to form the bottom of the slot because of their excellent resistance to abrasion and attack from iron scale. Fire brick in this location had to be replaced weekly—TAYCOR brick average three months. Very little scale or slag stick to the TAYCOR brick and that which does cleans off easily.

CROSS SECTIONAL VIEWS OF FORGING FURNACE

- RAMMED CHROME ORE
- TASIL HYDROCAST #402
- TAYCOR BRICK
- TASIL TILE
- FIREBRICK OR INSULATING BRICK
- FIREBRICK

If your heavy-duty or high-speed heating and heat-treating furnaces still require too-frequent shutdowns for re-lining, investigate the advantages of Taylor Sillimanite. Write direct, or contact the Taylor Representative in your area, for recommendations on your furnace problem. No obligation, of course.

Refractorers to industry since 1864.

Exclusive Agents in Canada:
REFRACTORIES ENGINEERING AND SUPPLIES, LTD.
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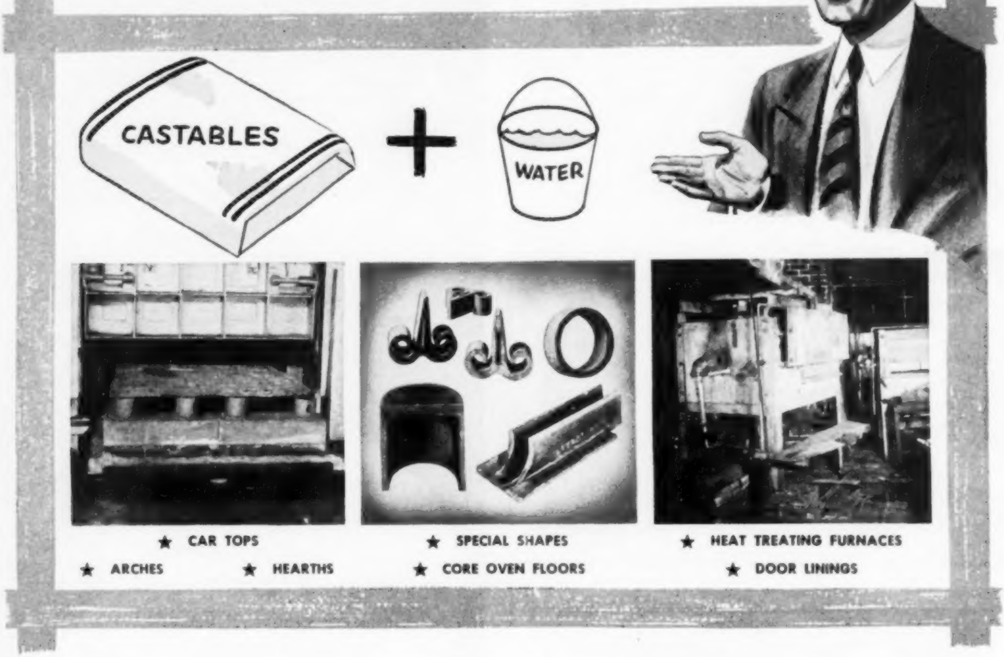
TAYLOR · TAYLOR SILLIMANITE · *The* **CHAS. TAYLOR SONS** *Co.*

REG. U. S. PAT. OFF.

MANUFACTURERS OF REFRACTORIES · CINCINNATI · OHIO · U. S. A.

Here's the most convenient way to make Refractory Concrete:



IT'S THAT SIMPLE—Castable Refractories completely eliminate the need of finding suitable aggregates . . . and grading them to the right sizes. Packaged Castables come to you with Lumnite* calcium-aluminate cement and selected aggregates already mixed—needing only addition of water. The resulting Refractory Concrete reaches service strength in 24 hours or less.

This convenient way of making Refractory Concrete speeds work and cuts labor costs. It simplifies tough jobs—and some Castables are suitable for use at temperatures of 3000°F. or higher.

REFRACTORY CONCRETE made with Castables is the *adaptable* refractory. Easy to place in any size or shape. No cutting or fitting necessary when you pour furnace walls, door linings and special shapes. There's no volume change to bother about. Build heat resistant floors, furnace walls, arches and hearths—Refractory Concrete withstands severe thermal shock, resists spalling.

In fact, you'll find Castables tailor-made for speed and convenience on many Refractory Concrete jobs. Handy for repairs, too.

CASTABLES to meet specific temperature and *insulation* requirements are made by manufacturers of refractories and sold by their distributors. For further information, write to LUMNITE DIVISION, Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, N. Y.

"LUMNITE" is the registered trade mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.

MP-L-54

ATLAS® LUMNITE for INDUSTRIAL CONCRETES

REFRACTORY, INSULATING, OVERNIGHT, CORROSION-RESISTANT

A UNIVERSAL ATLAS PRODUCT

"THE THEATRE GUILD ON THE AIR"—*Sponsored by U. S. Steel Subsidiaries—Sunday Evenings—NBC Network*

"no more GAMBLING on tool steel selection"

[1/3 actual size; Selector is in 3 colors]

Here's how it works:

To use the Selector, all you need know is the characteristics that come with the job: type and condition of material to be worked, the number of pieces to be produced, the method of working, and the condition of the equipment to be used.

FOUR STEPS—and you've got the right answer!

1. Move arrow to major class covering application
2. Select sub-group which best fits application
3. Note major tool characteristics (under arrow) and other characteristics in cut-outs for each grade in sub-group
4. Select tool steel indicated

That's all there is to it!

Here's an example:

Application—Deep drawing die for steel

Major Class—Metal Forming—Cold

Sub-Group — Special Purpose

Tool Characteristics—Wear Resistance

Tool Steel—Airdi 150

One turn of the dial does it!

And you're sure you're right!!

Since the first announcement, hundreds of tool steel users have received their CRUCIBLE TOOL STEEL SELECTORS. The comments received indicate that this handy method of *picking the right tool steel right from the start* is going over big.

"Handiest selector I've ever seen"

"No more gambling on tool steel selection"

"You're right, the application should dictate the choice of the tool steel" . . . and many, many more favorable comments.

You'll want your CRUCIBLE TOOL STEEL SELECTOR. It uses the only logical method of tool steel selection—begin with the application to pick the right steel! And the answer you get with one turn of the Selector dial will prove satisfactory in every case, for the CRUCIBLE TOOL STEEL SELECTOR covers 22 tool steels which fit 98% of all Tool Steel applications. ALL the tool steels on the Selector are in Warehouse Stock . . . that means when you get the answer, you can get the steel . . . fast!

Write for your Selector today! We want you to have it, because we know you've never seen anything that approaches your tool steel problems so simply and logically. Just fill out the coupon and mail. Act now! CRUCIBLE STEEL COMPANY OF AMERICA, Chrysler Building, New York 17, N. Y.

Crucible Steel Company of America
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New York 17, N. Y.

Gentlemen:

Sure! I want my CRUCIBLE TOOL STEEL SELECTOR!

Name________________ Title________

Company________________

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CRUCIBLE first name in special purpose steels

TOOL STEELS

fifty years of Fine steelmaking

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give mold and bacteria the boot with DOWICIDE PRODUCTS

Salmonella Typhosa Bacteria

You can protect soluble oils from mold and bacterial attack by giving them the "boot" with Dowicide products. When you use these Dow industrial germicides and fungicides, you put an end to production delays and material wastes caused by soluble oil emulsions and coolants going "sour."

It means that you'll no longer be bothered by rusted parts and machines, clogged drains and pipes that are the result of emulsion breakdown due to bacterial action. There [illegible] substantial savings in machine down-time and man hours, formerly required to replace "sour" emulsions and clean up equipment. Add to these preventative features the plus factor of greater service life for your soluble oil emulsions and you will realize *it costs you money not to incorporate Dowicide* products in your soluble oil emulsions and coolants. Give mold and bacteria the "boot" today by putting these products to work in your plant.

Dow maintains complete laboratory facilities to help you solve your problems. Contact your nearest sales office or write direct to Midland.

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Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle
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CHEMICALS
INDISPENSABLE TO INDUSTRY AND AGRICULTURE

Reynolds

ALUMINUM REPORTER

★ ★ ★ Seventh in a Series to Industry on Aluminum Uses and Developments ★ ★ ★

HEAT-TREATABLE ALUMINUM EXPANDS USES

Aluminum Pipeline in Use 1½ Years Shows No Corrosion

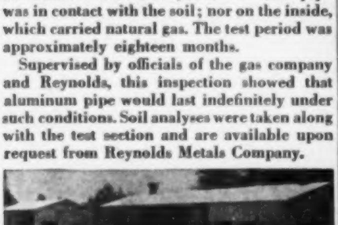
Recent uncovering of the 40-foot bare aluminum by-pass installed approximately eighteen months ago in the Alabama-Tennessee Natural Gas Company's 8-inch aluminum pipeline revealed absolutely no discoloration or corrosion of any sort.

Unretouched photograph showing aluminum pipeline section after seventeen months underground.

This section of pipe was installed without any protective coating or wrapping to test the natural corrosion-resistance of aluminum.

Careful inspection both inside and outside was made to determine any sign of wear or corrosion. No corrosion of any type could be found on the outside, where the bare pipe was in contact with the soil; nor on the inside, which carried natural gas. The test period was approximately eighteen months.

Supervised by officials of the gas company and Reynolds, this inspection showed that aluminum pipe would last indefinitely under such conditions. Soil analyses were taken along with the test section and are available upon request from Reynolds Metals Company.



Aluminum pipeline after being removed from ground. Note absence of corrosion in this unretouched photo.

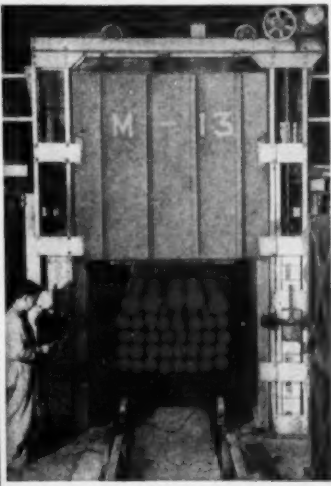
For further information on how the adaptability and corrosion resistance of aluminum can be applied to your product or problem, contact the Reynolds office or distributor listed under "Aluminum" in your classified telephone directory. Or, write to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

Four Part Book Has Valuable Information for Both Non-Technical Men and Metallurgists

Until recently, little information has been available on methods of heat treating the aluminum alloys. There has been a great need for this information since aluminum has become one of America's foremost metals.

The improved strength, hardness and temper of heat-treatable aluminum, especially the comparatively new 75S alloy, have greatly expanded the use of this lightweight metal in almost all industries. Now aluminum can be used in more places and for more purposes than ever before.

A 144-page illustrated book, "Heat Treating Aluminum Alloys," that brings together all the latest information on the subject in a form readily usable by both the non-technical man and the highly trained technician is now available from the Reynolds Metals Company.

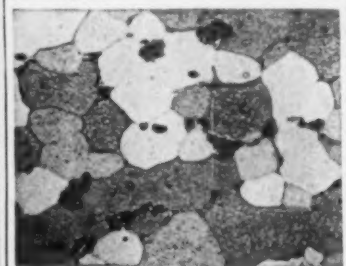


A 30,000 pound soaking furnace for handling billets. Note connections to thermocouples imbedded at various points in the load.

The book was prepared with the assistance and collaboration of some of the country's leading metallurgists and organizations. It contains photomicrographs, like the one in the column at right, showing the crystal structure for various treatments and alloys.

Divided into four parts for ready understanding and use, the book is handy for both desk and shop reference. Section One breaks down the subject into easily understandable concepts for the non-technical reader. Section Two presents in brief tabular form the recommended heat-treating cycles for specific aluminum alloys. Section Three is a technical discussion of the various treatments, possible difficulties and their cure. Section Four contains tables of mechanical properties for both wrought and cast alloys.

Application of the methods described in this book can improve the quality of your product and mean more profit for you through fewer rejects.



Structure of incorrectly heat-treated aluminum alloy R301. Excessively high temperature resulted in melting certain constituents at grain boundaries. Kellers etch, 500 X.

And if you have a *special problem* on design or fabrication with aluminum, take advantage of the trained staff of Reynolds Aluminum specialists waiting to help you. For prompt service, call the Reynolds office or distributor listed under "Aluminum" in classified telephone directories.

(Instructors are invited to request copies of this book for their senior and graduate engineering students. A 24-page condensation is also available without charge to other students.)

For your free copy of the valuable handbook, "Heat Treating Aluminum Alloys" plus a complete index of Reynolds technical literature, request today on business letterhead (otherwise price is $1.00). Write to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

MORE INTERESTING NEWS ABOUT ALUMINUM ON NEXT PAGE

(Continued From Preceding Page)

Roll-Formed Sections Ideal for Many Aluminum Applications

The continuous process of cold roll-forming aluminum into sections of various shapes is one of the valuable services made available to manufacturers by Reynolds Parts Division.

In many assemblies, the use of long roll-formed sections results in more efficient operations and a considerable scrap saving. Accuracy of roll-formed parts is usually maintained more closely than that of parts produced by other forming processes, thereby promoting interchangeability. Clear smooth finishes are easily obtained by roll-forming.

These advantages have been found to be of tremendous value to users of mouldings, structural parts, angles, channels, hat sections, zees, butt seam tubing, lock seam tubing and many miscellaneous shapes.

Among these users are manufacturers of automobiles, railroad and marine equipment, busses, trucks, trailers, aircraft, farm and ranch gates, clothes dryers, scaffoldings, ladders, screens, storm sash, television antennae, masts, siphon tubing, building products and many others.

For example, the Reynolds Fabricating Service furnishes roll formed hat sections to the Alprodco Company of Mineral Wells, Texas. These sections are the basis for an all-aluminum ranch and farm gate sold in great numbers by this company throughout the West. The sections are used for vertical, horizontal and diagonal members of the gate.

This is only one example of the valuable service made available to manufacturers through the use of the Reynolds Parts Fabricating Service. Formed or partially formed parts are delivered to the manufacturer ready for finishing and assembly, resulting in scrap savings averaging 30%—often as high as 75% —plus valuable time savings.

Reynolds Parts Fabricating Service is a complete service with equipment for shearing, forming, drawing, tube bending, roll-forming, roll shaping, riveting, welding and finishing. The Service is set up to work with all manufacturers, regardless of size, to secure coordination of all resources to expand the nation's production capacity on defense orders.

For complete information on how the Reynolds Parts Fabricating Service can help you, write for the free booklet, "Pounds of Parts . . . instead of Pounds of Metal." And for assistance on your particular requirements, call the Reynolds office listed under "Aluminum" in your classified telephone directory. Or, write Reynolds Metals Company, 2065 South Ninth Street, Louisville 1, Kentucky.

Be sure to see our booth, F-325, at the Metal Exposition—Detroit, October 15-18. We'll be pleased to answer your aluminum design or fabrication questions—and show you a host of aluminum improved products.

Aluminum Pigments Offer Variety of Finishes For Beauty, Protection and Durability

If your product cannot be made of aluminum, the next best thing is to take advantage of one of several attractive aluminum finishes.

When mention is made of aluminum paints, the usual thought is of the bright, silvery surface most often seen in "leafing" type paints. But there are other types of aluminum pigment finishes, chief among which are the "wrinkle," "hammered metal" and "polychromatic" types.

The "wrinkle" type is widely used for an attractive, glare-free finish on such objects as typewriters and other office machines. This finish is produced by coating the metal with a special opaque paint to which "non-leafing" aluminum pigment has been added. The wrinkled effect is achieved by a short baking operation. Advantages of this type of finish are the glare-free surface and defect-hiding properties. Minor surface scratches are hidden without buffing.

The "hammer" type finish, so called from its resemblance to the effect achieved by light tapping on metal with a ball-peen hammer, is widely used to obtain a smooth, easily cleaned surface with multi-colored effects on such objects as thermos jugs, ashtray stands, automatic vending machines, lawn mowers, etc. This finish will also cover minor surface defects. The "non-leafing" aluminum pigmented paint is formulated in such a manner that, having been sprayed on the object and left to dry, the paint automatically produces a "crater" or "hammered" effect.

The third finish, widely used for its lustrous beauty, is the "polychromatic" coating. This finish is in great demand for automobiles because of the added durability and beauty imparted by the reflective aluminum pigment. "Non-leafing" aluminum flakes remain suspended in the transparent color lacquers or enamels giving a metallic iridescence. Examples of this type of pigment finish are the sparkling, jewel-like colors you see more and more on the late model automobiles. Polychromatic effects are also favored for plastic materials such as shower curtains, chair-coverings, raincoats, etc.

To learn more about these attractive and durable finishes, call the Reynolds office listed under "Aluminum" in your classified telephone directory. Or, write to Reynolds Metals Company, 2576 South Third St., Louisville 1, Ky.

Aluminum Gains in Favor for Curtain Wall Construction

The term "curtain wall" is a designation for non-structural closures for the structural frame work of modern buildings.

Curtain wall panels are prefabricated units of insulation material sandwiched between facings of plain or decoratively embossed aluminum—or aluminum for the exterior and other finishing material inside—similar to plywood but considerably thicker.

There are several curtain wall panel designs with varying methods for interlocking and sealing. A number of factory and office buildings have already employed this new construction method with highly satisfactory results.

The advantages of aluminum for curtain walls are apparent. Light weight combined with great strength, natural attractiveness and resistance to rust and corrosion make aluminum an ideal material for modern construction.

A Reynolds Aluminum Specialist will be glad to discuss all the advantages of aluminum in your products. Call the Reynolds office or distributor listed under "Aluminum" in your classified telephone directory or write to Reynolds Metals Company, 2576 So. Third St., Louisville 1, Ky.

Reynolds Wrap is now "all out" for defense

Return Flight Guaranteed!

Reynolds Developing World's Biggest Bauxite Deposit in Jamaica, B.W.I.

A 40,000 to 50,000 acre tract of Jamaican real estate has been acquired by Reynolds Jamaica Mines, Ltd., a subsidiary of Reynolds Metals Company. The tract is said to contain by far the most important bauxite ore body ever discovered. *This deposit has enough bauxite to furnish the United States with low-cost aluminum for many decades.*

The extensive Jamaican mining project involves total expenditures of about 14½ million dollars. Construction of a pier and harbor facilities, a drying plant, overhead tramways and other auxiliary equipment is well underway and scheduled for completion early in 1952. Net result will be a reliable source of bauxite to supply the U. S. with low-cost aluminum for generations to come.

The use of low-silica Jamaican ore to supplement high-silica Arkansas bauxite will also permit the use of even lower grades of domestic bauxite than are presently regarded as usable, and will correspondingly enlarge the effective reserve.

Most of the bauxite used in the U. S. by companies other than Reynolds now is imported from Dutch Guiana, a distance of about 2500 miles. Jamaica is located only 1000 miles from Gulf ports in the U. S.

Printed in U.S.A.

"Increased Production ...Improved Quality"

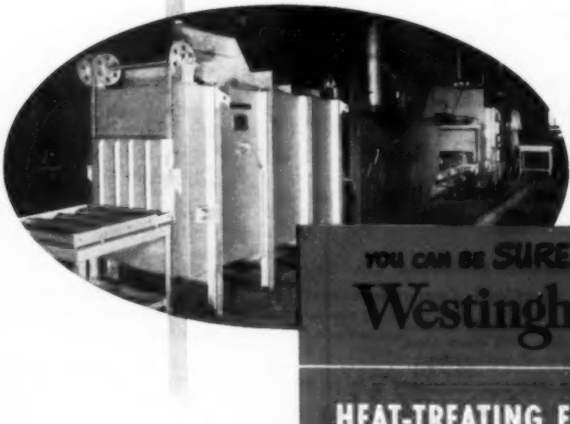
...says large tool company

"Stepped up production and improved the quality of our products," says a large tool company of this Westinghouse electrically heated, gas carburizing furnace. Steel parts ... of a wide variety of shapes and sizes ... are carburized, quenched, washed, drawn and discharged. Operation is straight line and completely automatic.

The result: Precise, *uniform* carburization of all parts, faster operation, and elimination of bottlenecks caused when trays must be manually removed.

A Westinghouse gas-fired Endogas generator provides the proper, safe controlled atmosphere. In addition, all auxiliary equipment is also Westinghouse, including motors, controls and material handling equipment ... *a complete "packaged" installation from a single source.*

Gas-fired or electric, there's a Westinghouse furnace to meet every heat-treating need. Westinghouse Electric Corporation, Industrial Heating Works, Meadville, Pennsylvania. J-10369



IF YOUR PRODUCT CALLS FOR HEAT-TREATING ... IT CALLS FOR A WESTINGHOUSE FURNACE ... GAS OR ELECTRIC

YOU CAN BE SURE... IF IT'S

Westinghouse

HEAT-TREATING FURNACES

SEE THE WESTINGHOUSE FURNACE EXHIBIT AT THE METAL SHOW, BOOTH G-430

Effect of Sinter on Blast Furnace Production*

A METHOD is submitted for determining the effect of sinter on blast furnace production, with the use of statistical analysis of daily operating data. For this purpose, a statistical study was made, using 1000 daily values from a blast furnace having a hearth diameter of 18 ft. and a capacity of 800 tons per day.

It has been clearly indicated by a recent survey of sinter plants that the effect of using sinter in the blast furnace is difficult to evaluate. This is because the true effect is usually more or less obscured by the influence of other operating factors.

The study was made by analyzing the two variables, blowing rate and efficiency, and their related factors as shown in the tabulation:

I. Blowing rate (cu.ft. of air per day).
  1. Physical characteristics of coke.
    a. Size, shatter, stability, etc.
  2. Physical characteristics of metallic burden.
    a. Hardness and size distribution of ore.
    b. Percentages of sinter, scrap, etc.
  3. Mechanical delays.

II. Efficiency (cu.ft. of air per ton of iron).
  1. Richness or iron content of burden.
    a. % sinter.
    b. % scrap.
    c. % any special materials.
  2. Slag volume.
    a. Silica and other gangue in metallic burden.
    b. Ash and sulphur in coke.
  3. Reducibility of ores.
  4. Moisture in blast.
  5. Required analysis of iron.
    a. Silicon, manganese and sulphur.
  6. Stock column movement.
    a. Smooth or rough.

Benefits from sinter would be expected to come in two ways. First, it would increase the iron content of the burden. Secondly, it would be expected to give more voids of uniform character in the ore layers which should contribute to increased gas-solid contact in the stack. This should help to offset the loss of reducibility attributed to the use of sinter. Whether it actually does or not is still a question to be answered.

The influence of sinter on operating characteristics is shown graphically in five separate figures. Respectively, they indicate:

1. If the amount of metallic burden plus flux required to make a ton of pig iron can be decreased by 100 lb., production will increase 16 tons per day on the specific furnace involved.

2. Each per cent of sinter in the burden will decrease the total material required by about 8 lb. per ton of iron produced. Also at 50% sinter, total material required is decreased by 400 lb. per ton of iron and production increased 64 tons per day.

3. Correlating per cent sinter directly with pig iron production shows an increase of 57 tons pig iron per day when using 50% sinter.

4. Plotting blowing rate against efficiency indicates the optimum blowing rate consistent with maximum production.

5. Comparing characteristic curves for two sinter levels shows

(Continued on p. 164)

*Abstract of "The Effect of Sinter on Blast Furnace Production as Determined by Analysis of Daily Operating Data", by W. E. Marshall, a paper presented before the General Meeting of the American Iron and Steel Institute at New York, May 23-24, 1951.

Effect of Sinter on Blast Furnace Production

(Continued from p. 162)

Operating Data

Test Group	Blowing Rate M Cu.Ft. per Min.	Air Cu.Ft. per Ton	Coke Lb. per Ton	Production Tons per Day
Original	52.6	90.7	1632	842
Low sinter	53.0	91.3	1634	844
High sinter	52.1	90.1	1630	840

Burden Data

Test Group	Composition of Burden				Metallic Burden	Flux
	Sinter	Scrap	Misc.	Ore		
Original	54.8	6.6	6.8	31.8	3418	726
Low sinter	47.7	6.9	7.1	38.3	3449	722
High sinter	61.9	6.4	6.6	25.1	3387	729

that a higher sinter burden causes lower efficiency to set in at a lower blowing rate.

For further study of the effect of sinter, the 1000 daily values were split into two sets of 500 each, so that one set contained low values and the other high values of sinter. The average values of the two sets of 500 and the original set of 1000 are shown in the tables.

There is appreciable difference in production and coke rate between the low and high values of sinter. However, the air per ton of iron was 1200 cu.ft. less in the case of high sinter, even with 0.5% less scrap. The average blowing rate was also slightly less for the high sinters. Had it not been for these two factors, production would have been 12 to 15 tons more per day for the higher sinters.

The foregoing procedure has been presented, not as a general solution to the problem of sinter utilization for everybody, but to demonstrate the necessity for serious effort to find out what kind of sinter is best for the blast furnace, and how to make it. This technique is one that will give more information and understanding about any blast furnace burden.

Characteristics of sinter will vary from company to company and plant to plant, depending on the materials available for its making and what it replaces in the burden. An industry-wide program to evaluate sinter is faced with a good many organizational difficulties. Adequate sampling and testing of such a nonuniform product would cover a long period of time and be expensive.

If such a program is organized, each company participating might do as follows:

1. Make the kind of sinter he believes best.
2. Describe this sinter for the experimental period with agreed tests, adequate in number to show the significant differences between sinter made at the various plants.
3. Run a blast furnace test at each plant comparing agreed percentages of sinter in the burden to an all-ore burden composed of ores that would be used if sinter were unavailable.

(Continued on p. 166)

Effect of Sinter on Blast Furnace Production

(Continued from p. 164)

4. Conduct the blast furnace test in such a way that *(a)* the relation between blowing rate and efficiency, *(b)* blowing rate and production, and *(c)* blowing rate and flue dust can be obtained for each burden.

5. From this information it will be known whether sinter *(a)* permits higher blowing rates without loss of efficiency, thus increasing production more than its increased iron content would do alone, *(b)* increases efficiency and production only proportional or less than proportional to its iron content, *(c)* permits higher blowing rates without increasing dust losses.

Such a program might be viewed askance in fear of lost production. Nevertheless, until it is carried out, the sinter situation will continue to be confused. Actually, if such a test were carefully planned, the variation introduced by it might have no more effect on annual production than unforeseen and unplanned difficulties that always occur.

A. J. Hoch

Tensile Strength of Warm Worked Austenitic Steel*

Wrought alloy G18B, developed in England during the war for high-strength high-temperature application as disks in jet engines, has been improved materially by "warm working" at temperatures within the precipitation range. This steel has the following composition: C 0.4, Mn 0.8, Si 1.0, Ni 13.0, Cr 13.0, Co 10.0, W 2.5, Mo 2.0, and Cb 3%. As engine operating conditions became more severe, excessive stretch occurred at the comparatively cool center of G18B disks and an effort was made to improve the inherently low proof stress without adversely affecting the adequate high-temperature creep and rupture strengths. Age hardening and cold working improved room-temperature proof stress materially, but respectively lowered and gave erratic improvements in creep strength along with lower rupture strength. Experiments with warm working, both on

(Continued on p. 168)

*Abstract of "Effect of Warm Working on an Austenitic Steel (G18B)", by G. T. Harris and W. H. Bailey, Symposium on High Temperature Steels and Alloys for Gas Turbines, Iron and Steel Institute, February 1951, p. 60.

Tensile Strength of Warm Worked Austenitic Steel

(Continued from p. 166)

an experimental and production basis, indicated that both the low and high-temperature properties of G18B were improved with this treatment.

Experimental Warm Working — Investigation was made of the response of solution treated (at 2370° F.) bar stock of G18B to warm working *(a)* by pressing between flat dies, *(b)* in tension, and *(c)* by stamping in closed dies. From the work in flat dies between 1200 and 1650° F. it was found that the properties improved with increasing warm working stresses, and that these stresses should be higher than the proof stress at the warm working temperature to produce a marked improvement in properties. There was an indication that deformation during warm working could be used as a criterion for the amount of working applied.

Effect of Warm Working

Warm Working Method	0.1% Proof Stress	Creep Test*	
		Creep Rate†	Rupture Time‡
Solution treated	31,400	300	100
Solution treated and aged	44,800	>1000	15
Pressing	72,800	. .	. . .
Tension	87,400	11	710
Drop stamping	70,300	2	560

*35,800 psi. at 1290° F. †Per hr. × 10^6, minimum. ‡In hours.

Warm working in tension improved room-temperature proof stresses and hot rupture strength almost linearly with increasing total strain (at constant strain rate) up to 8% (and hence also with increasing stress). Working temperatures between 1110 and 1470° F. were not critical except in their influence on the stress applied to yield a given strain. While proof stresses were found to increase with decreasing strain rates (from 10^{-1} to 10^{-3} per min.) and constant strain, this may have been an age hardening effect resulting from the longer times at temperature for the slower rates.

Having established that warm working enhances the properties of G18B it was necessary to investigate the only available method of obtaining the stresses necessary in production of large disks — that of drop stamping in closed dies. While most of the deformation took place in the first one or two hammer blows, the proof stress continued to increase up to 24 blows. This indicates that total energy absorbed rather than amount of deformation controls the proof stress. Creep and rupture strengths were improved up to about six warm working blows, after which these properties became constant. Proof stress increased with working temperature only after more than ten blows, but rupture and creep strength reached an optimum at warm working temperatures around 1200 to 1290° F. after six blows. Warm working the alloy in the as-forged condition gave similar proof stress improvements to those on previously solution treated material, but rupture strengths were no better than for material that was not warm worked.

The maximum properties obtained by each of the three warm working methods are given in the table. Maximum proof stresses and creep properties in this table were not

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Tensile Strength of Warm Worked Austenitic Steel

(Continued from p. 168)

necessarily for the same condition of warm working. There was little significant difference to be found between tensile or creep properties obtained from pressing and from drop stamping.

Production Warm Working — Production warm working of disks of G18B was done on a 10-ton drop hammer at 1290° F., both in flat and contour dies. Although the process must be carefully controlled, it has given disks uniformly good properties and satisfactory performance under the most severe flight conditions. Room-temperature tensile ductility tended to be lower (8 to 15% elongation) at the disk center than at the rim (about 25% elongation). Tensile strengths were uniform throughout the disk, although not as high as those obtained on bar stock. This difference is dependent on the size of the disk and the capacity of the drop stamp.

Proof stress experiments with various size disks indicated that there is little advantage in warm working a disk larger than 24 in. diameter and 5 in. thick with a 10-ton drop hammer. However, good proof stresses can be obtained at the center of larger disks by limiting the warm working area to only the center region of the disk. By determining the work affected zones from "iso-hardness" studies, tool designs and procedures involving two or three working stages were established for producing uniformly warm worked stub shaft disks. It was established that the beneficial effect of warm working on the creep strengths of disks was still in evidence after testing times of up to 10,000 hr.

Because of the excellent tensile properties obtained by warm working in tension, the difficult but probably practical procedure of imposing a radial tensile stress at the centers of large disks by hot spinning is considered a possibility for the future. Warm working should also be suitable on bar material for turbine blade production and for applications outside the gas-turbine field.

E. E. Reynolds

Welding Characteristics of Two Austenitic Steels Used for Gas-Turbine Rotors*

Investigations have been carried out on the weldability, the weld metal characteristics, and the properties of welded joints, of two austenitic creep-resisting steels developed in Britain.

ARC WELDING OF G18B STEEL

The austenitic steel G18B is a high carbon Cr-Ni-Co-Mo-W-Cb composition of lower alloy content than our American super alloys. A typical composition is 0.4 C, 14 Cr, 13 Ni, 11 Co, 1.5 Mo, 2.7 W, 2.6% Cb. In the as-cast state, G18B has better creep properties than in the wrought and heat treated condition, but with reduced ductility. For this research, special electrodes were developed, using G18B wire. The coating was of the usual silicate-bonded lime-fluorspar type, and contained suitable amounts of alloys to replace the losses which

(Continued on p. 172)

*Abstract of "Weld-Metal Properties and Welding Characteristics of Two Austenitic Steels Used for Gas-Turbine Rotors", by E. Bishop and W. H. Bailey, Symposium on High-Temperature Steels and Alloys for Gas Turbines, Iron and Steel Institute, February 1951.

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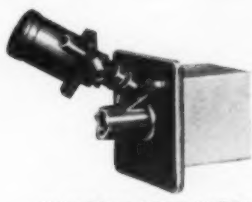

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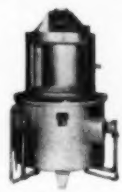

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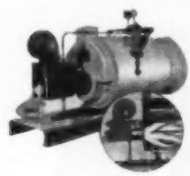

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Welding Characteristics of Two Austenitic Steels

(Continued from p. 170)

occur in the welding arc. The only modifications were a slight drop in carbon and an increase in tungsten.

The electrodes were subjected to extensive usability tests, including restrained butt-welds. No tendency to crack formation was ever observed.

The microstructure of G18B plate material consists of fine carbide particles in an austenitic matrix; the weld metal has a fine dendritic structure. No traces of ferromagnetism have ever been detected in this weld metal ($\mu<1.1$), so that the interdendritic material must consist of carbides, intermetallic compounds, and austenite of a composition slightly different from that of the matrix.

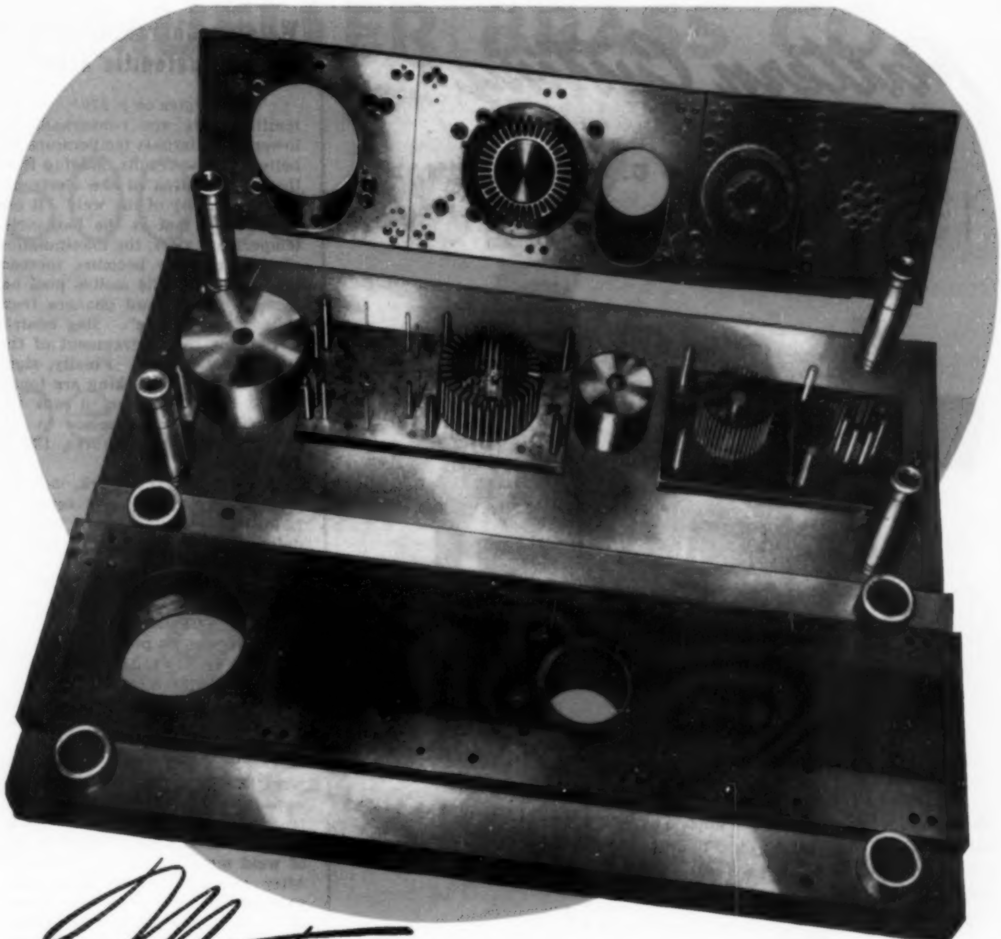
Mechanical properties of the weld metal were obtained on all-weld-metal samples. Specimens were tested in the as-welded condition, after stress-relieving for 1 hr. at 1200° F., and after solution treatment at 2400° F. In the as-welded condition a very good combination of properties was obtained (100,000 psi. ultimate tensile strength, 15% elongation in 2 in., 25% reduction in area, 17 ft-lb. Izod). Because the weld metal had better properties in the as-welded state, solution treatment was unnecessary.

Two types of arc welded butt joints were studied, one a 60° included angle "V" joint, the other a 15° included angle "U" joint. The root radius of the U was ¼-in., with root face of ⅛ in., and a root gap of $\frac{1}{16}$ in. The arc welding was carried out as usually recommended for austenitic electrodes. "Weaving" was strictly avoided. Separate experiments using a wide weaving technique showed no apparent ill effects; however, this was considered poor practice and was not recommended, because it also introduced some difficulty in slag control.

The slag was very carefully removed between passes. After chipping and brushing, the weld surface was examined with a lens, and all traces of slag were removed. This was very time-consuming, and the average cleaning operation took six to eight times as long as did the actual welding.

The authors comment on the effects of preheating and of using high interpass temperatures. From their experience, as far as aus-

(Continued on p. 174)



Welding Characteristics of Two Austenitic Steels

(Begins on p. 170)

tenitic steels are concerned, the lower the interpass temperature the better are the results, judging from the manipulation of the electrodes and the quality of the weld. It has been found that as the base-metal temperature rises, the manipulation of the electrode becomes increasingly difficult. The molten pool becomes enlarged and changes from "quiet" to "boiling". Slag control is difficult, and entrapment of the slag occurs readily. Finally, signs of porosity and cracking are found in the crater. Hence, it was the authors' standard practice to use low interpass temperatures, 120 to 140° F. maximum.

Throughout the work, no test plate was rejected as a result of radiographic examination, and no defects were observed, with the exception of occasional slight porosity at the extreme ends, where it was impossible to avoid superimposing a number of craters

There was no point of superiority for either the "U" or the "V"-type joints when all the data were considered In the as-welded condition it would appear that the "V"-type weld was more ductile, inasmuch as the bend specimens were bent to a greater angle. The difference was not apparent in the tensile tests, because the gage length included an average of about ½ in. of weld metal and 1½ in. of plate. After stress-relieving, and more particularly after solution treatment, there was no marked difference between the two types of joint. Possibly the slight difference in the as-welded condition was due to the different systems of residual stresses in the two types of joint. Stress-relieving, as expected, had very little effect on the mechanical properties of the welded joints, and it was questionable whether the residual stresses were in fact removed by this treatment. The data were reported to show that welded joints suffered no ill effects on heating to medium temperatures.

All creep tests were carried out at 1290° F., which is a normal operating temperature for G18B. The minimum creep rate, rupture time, and elongation at rupture, showed close agreement between the results on "U" and "V" joints. It was concluded that there was no difference in creep strength between "U" and "V" joint welds for G18B in the

(Continued on p. 176)

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Welding Characteristics of Two Austenitic Steels

(Begins on p. 170)

as-welded condition at 1290° F. Furthermore, at this temperature the creep strength of the actual welds was approximately 20 to 30% higher than that of solution treated wrought material. This higher strength was more evident when the rate of creep rather than the time-to-rupture was considered, but the ductility of the weld metal was rather lower than that of the parent material.

Two series of tests of the effect of heat treatment after welding were made: *(a)* on welds solution treated at 2400° F. (the standard heat treatment for G18B), and *(b)* on welds stress-relieved at 1200° F. after welding. Within the limits of material uniformity and experimental technique, both the solution treated and the stress-relieved G18B welds had a creep strength at 1290° F. equal to that of standard material (minimum creep rate 10^{-5} in. per in. per hr. at 22,000 psi.).

ARC WELDING OF R20 STEEL

Austenitic R20 steel has a chemical composition resembling the American Type 347, with high nickel and carbon. A typical composition is 0.14 C, 19 Cr, 14 Ni, 1.5% Cb. Two electrodes were studied: R20 wire specially coated with a flux very similar to that used on G18B, to give weld metal of unchanged composition; and a proprietary electrode, giving a very similar type of weld metal.

The tensile and Izod impact test results on all-weld-metal specimens made from the two electrodes showed defective weld metal in the case of the proprietary electrode, the appearance of the fracture being oxidized. The unsatisfactory properties of the proprietary weld deposits were traced to numerous microcracks. These always occurred in multipass deposits, but could seldom be seen in single-pass welds.

The problem of microcracking has been studied very extensively in America (reference is made to seven papers in *The Welding Journal* and *Metal Progress*, but no completely satisfactory explanation has yet been given. Much investigation has been carried out by the authors into the causes and prevention of microcracking in fully austenite weld metals, and this work will be

(Continued on p. 178)

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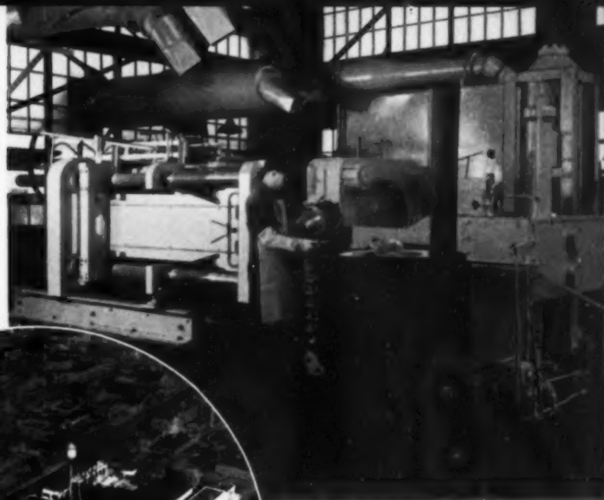

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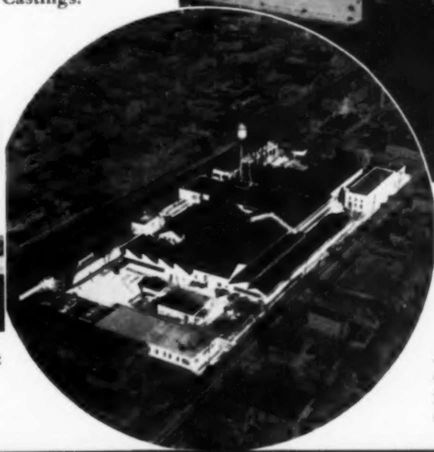

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These rivets are relatively soft, are always driven cold. If maximum softness is desired, 2S-O alloy may be used.

Alloy A17S-T4

Furnished in the heat treated condition and are driven cold as received. Not quite as strong as 17S-T4 rivets, but they eliminate reheat treatment and cold storage necessary on many sizes of 17S-T4 rivets.

Alloy 17S-T4

Usually furnished in heat treated condition. Small sizes may be driven cold. Larger sizes require reheat treatment and cold storage unless driven within a few hours after treatment.

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24S-T4

Strongest and most difficult to drive of the aluminum rivets. Generally used only in smaller sizes. They are supplied heat treated, but require reheat and cold storage.

53S-T61

Supplied in heat treated condition and are driven cold as received. They have stable mechanical properties, may be stored indefinitely. 53S-T6 alloy is slightly stronger, but requires more driving pressure.

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These are but a few of the interesting properties which merit your serious consideration when the free-cutting alloys are again available for unlimited use. Meanwhile, write for a free copy of the 178-page book, "Alcoa Aluminum and Its Alloys."

MECHANICAL PROPERTIES OF THE FREE-CUTTING ALLOYS

ALLOY	THICKNESS INCHES	TENSILE STRENGTH LBS./SQ. IN.	YIELD STRENGTH LBS./SQ. IN.	ELONGATION, % IN 4 DIA., MIN.
11S-T3	0.125 to 1.5	45,000	38,000	10
17S-T4	0.125 to 8.0	55,000	32,000	16
24S-T4	0.125 to 5.5	62,000	40,000	14
61S-T6	0.125 to 8.0	42,000	35,000	10

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Welding Characteristics of Two Austenitic Steels

(Begins on p. 170)

described in a future paper. Briefly, cracking occurs under the following conditions:

1. The absence of delta-ferrite in the structure.

2. The simultaneous presence of silicon in amounts exceeding about 0.40% and of columbium in excess of about eight times the carbon content.

3. Reheating of the metal to high temperatures (for example, by the deposition of later passes of weld metal). Thus, if an austenitic alloy containing silicon and excess columbium is heated within the range between about 1200° F. and its melting point, a characteristic grain-boundary precipitate is formed. Positive X-ray identification of the precipitate as a complex Fe-Cb-Si compound has been obtained, and it has been found that this structure normally occurs in austenitic steels under conditions cited in 1 and 2, but that it only leads to cracking when delta-ferrite is absent. The latter constituent, which also occurs at the grain boundaries of the austenite, inhibits the formation of cracks.

Accordingly, further electrodes were developed in which the silicon content and the columbium-carbon ratio of the weld metal were closely controlled. A tentative specification was drawn up to cover the weld metal composition deposited by electrodes for use in welding R20 steel forgings, as follows: C 0.12 to 0.16, Mn 0.7 to 1.5, Si 0.30 max., S 0.030 max., P 0.030 max., Cr 13.0 to 15.0, Ni 18.0 to 20.0, Cb 8 to 10 times carbon content.

Primary factor is rigid control of the silicon content. If this is kept below 0.30%, the permissible columbium limit may probably be raised, whereas with higher silicon contents, cracks may occasionally occur with quite low columbium-carbon ratios. On the other hand, the columbium-carbon ratio must remain adequate to prevent weld decay. To assist electrode manufacturers, it will be necessary, the authors say, to provide special heats of R20 steel for wire production, having a maximum limit of 0.20% of silicon.

All-weld-metal bars were tested in the as-welded condition, after stress-relieving for 1 hr. at 1200° F., and after normalizing at 2000° F., and a series of "U" and "V" butt

(Continued on p. 180)

Welding Characteristics of Two Austenitic Steels

(Begins on p. 170)

welds in 1-in. thick R20 plates were tested. Preheating was avoided and low interpass temperatures were used. The finished welds were machined and radiographed. Again, the standard achieved was very high and no defects were observed, except for occasional porosity at the extreme ends. Full solution treatment was inapplicable, as it would rarely be carried out on welded assemblies. These welded specimens were extremely satisfactory. The weld metal closely matched the parent plate in chemical composition; it had excellent mechanical properties (85,000 psi. ultimate tensile strength, 30% elongation in 2 in., 60% reduction in area, 40 to 50 ft-lb. Izod), and was very sound and free from defects.

Creep tests on R20 welds were carried out at 1200° F., which is a reasonable operating temperature for this material. The strength of the actual weld deposit (that is, virtually as-cast material) was apparently very similar to that of the parent metal, since in these tests there was no discrepancy between results on large and small specimens. This was further confirmed by the fact that some of the tests fractured in the weld and others in the parent metal, whereas with the G18B steel all the fractures occurred in the parent metal.

Duplicate tests were made to check the relative advantages of "U" and "V" joint welds, and samples were tested in the as-welded condition and also after normalizing from 2000° F. In general, the agreement was good between the two types of weld, so that no distinction needed to be made between the two. On the basis of rupture strength (500 hr. to rupture at 22,000 psi.), the R20 welds were very similar to standard material; they were a little stronger on the basis of creep strength. It was therefore evident that, as with G18B, the welding of R20 did not markedly affect its creep strength, and welds could be put into service without heat treatment after welding. While the effect of a low-temperature stress-relieving treatment was not investigated, it was thought that this would not produce any marked change in the creep strength, since it is merely equivalent to a very short time at service temperature without an applied stress.

(Continued on p. 182)

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Welding Characteristics of Two Austenitic Steels

(Begins on p. 170)

WELDING OF ROTOR ASSEMBLIES

To the best knowledge of the authors, the Swiss firm of Sulzer Brothers, Winterthur, have made the greatest advances in the welding of large high-temperature gas-turbine rotors. It is understood that individual G18B disk and drum forgings have been successfully arc welded, using G18B electrode wire of normal composition, coated with a neutral refractory of their own manufacture. The individual portions of the rotor were arc welded together, taking every precaution, and the joints were subsequently machined, polished, and etched, and proved to be free from cracks or defects. The assembled rotor was then cold spun at overspeed, and the welds were re-examined to prove that the radial strains developed during the test in no way induced cracks in the weld metal. Following these successful tests, the rotor was then bladed.

Gas-turbine rotors constructed in this way have already run for considerable periods under working conditions, with complete satisfaction. The excellent welding properties of G18B steel have thus been independently verified.

HALLOCK C. CAMPBELL

Properties of Electroplates*

As a broad classification, electrodeposition is used to achieve one or several of the following effects, either singly or in combination: decorative surfaces, protection of base metal from corrosion, increased hardness and reclamation of parts machined undersize, improvement of bearing properties, modification of electrical and thermal properties, improvement of luster and reflective properties, electrodeposition of alloys, fabrication of intricate shapes by electroforming, and other miscellaneous uses.

The typical plating specifications given are, in general, substantially lower in salt spray resistance re-

(Continued on p. 186)

*Abstract of "The Physical and Engineering Properties of Electrodeposited Metals", by J. S. Anderson, a paper presented before the Australian Institute of Metals, Physical Metallurgy Division, at the Symposium on Electrodeposited Metals, 1949.

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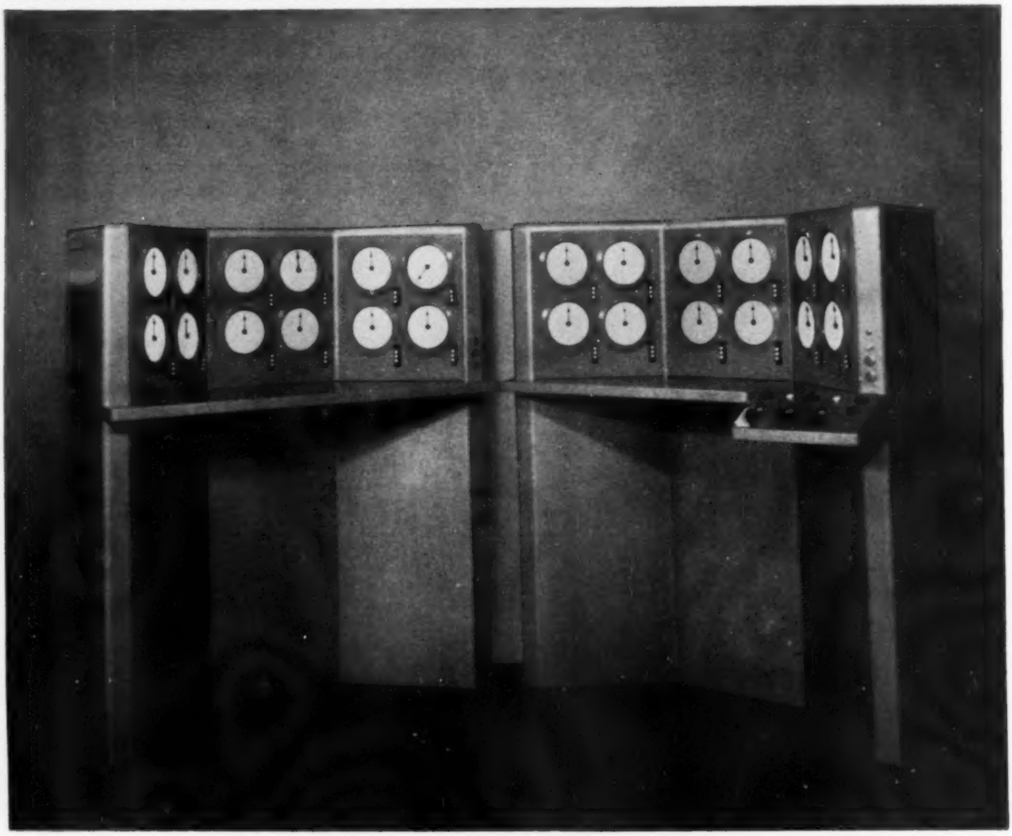

steel, cast iron, aluminum, brass, magnesium

Push button operation, clock dials are read directly in % concentration to provide accurate, reliable analysis in a matter of seconds. DIRECT READING ANALYSIS means increased furnace production, no heat lost due to "off analysis." Technical Bulletin #34 on the subject is furnished free and promptly to executive and technical personnel who request it on their letterhead.

Baird Associates will exhibit a model spectrographic laboratory and emission accessories in Booth H 427 during the Nat'l Metals Exposition in Detroit, October 15-18. We would be pleased to share any of your problems on instrumental analysis. Visitors to the show who are interested in seeing a Direct Reader in operation will please see P. C. Hutchinson in Baird Associates booth. Visit will be arranged through the courtesy of McLouth Steel Corporation.

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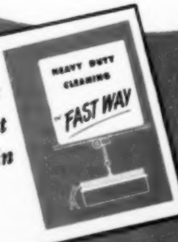

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Properties of Electroplates

(Continued from p. 182)

quirements than American specifications. For example, zinc or cadmium, 0.0005 in. thick on steel, is required to withstand only 48 hr. salt spray compared with 240 hr. for 0.0005 in. cadmium in American Specification QQ-P-416.

A table of Brinell hardness for electroplates is given as:

Chromium	400-950
Platinum	606-642
Rhodium	594-641
Palladium	190-435
Nickel	125-550
Iron	140-350
Copper	40-130
Silver	60- 79
Cadmium	12- 22
Zinc	40- 50
Tin	8- 9

When a composite plate of copper, nickel, and chromium fails as a result of high tensile stress, it is evident that most of the stress exists in the nickel plate. Since the tendency of highly tensile stressed nickel is to accelerate the rate of plate failure, an effort should be made to hold the stress to a minimum value. This can be accomplished by keeping the pH at the lowest operating value, maintaining the maximum temperature, careful control of addition agents, and taking precautions to plate from a clean and pure bath. The decorative chromium should be held to the minimum thickness.

The static properties of some steels are not adversely affected by embrittlement but the fatigue life is greatly impaired, and all parts subject to stress should be treated to remove hydrogen embrittlement before they are put into service. Acid pickling is responsible for embrittlement in most instances, and the effect increases with temperature up to approximately 120° F.

Hydrogen embrittlement may be removed and parts restored to nearly normal conditions by heating to a low temperature for some time, providing cracks have not developed after plating. If work is permitted to stand at room temperature for several days, hydrogen embrittlement is removed if the degree of embrittlement is slight. Several hours immersion in boiling water is sometimes used on low-carbon steel. However, for higher carbon steels used in high-tensile bolts and springs which are highly stressed, heating at 300 to 400° F. for 2 to 3 hr. is the practice recommended.

The electrical resistivity of plated

(Continued on p. 188)


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Properties of Electroplates

(Continued from p. 186)

coatings is tabulated and, as expected, silver, copper and gold head the list with resistivity values (microhm-centimeters) of 1.63 at 18° C., 1.72 at 20° C., and 2.44 at 20° C., respectively. Then follow chromium with 2.6 at 0° C., rhodium 5.11 at 0° C., zinc 5.75 at 0° C., cadmium 7.54 at 18° C., nickel 7.8 at 20° C., indium 8.37 at 0° C., cobalt 9.7 at 20° C., iron 9.8 at 20° C., platinum 9.83 at 0° C., palladium 11.0 at 20° C., tin 11.5 at 20° C., and lead with 22.0 at 20° C. This important property of electroplated metals is used extensively for electrical contact points, silver in particular being used because of its resistance to oxidation. An innovation of recent years is the plating of electrical circuits on plastic or other nonmetallic bases, a process similar to "printed circuits" now in use for the manufacture of compact, portable radio and other electrical equipment. This process involves the masking of all areas other than the electrical circuit, which is cut through the masking medium, and subsequent electrodeposition with silver or copper provides the current-carrying conductors of the circuit.

A table of thermal conductance values of 15 metals is given from the paper, "Physical Properties of Electrodeposited Chromium", by Brenner, Burklead and Jennings, *Journal of Research*, National Bureau of Standards, Vol. 40, 1948, p. 31-59.

The coefficients of friction of various metal combinations listed are:

METALS	STATIC FRICTION	SLIDING FRICTION
Steel on chromium-plated steel	0.14	0.12
Babbitt on chromium-plated steel	0.15	0.13
Steel on chromium-plated steel	0.17	0.16
Steel on babbitt	0.25	0.20
Babbitt on babbitt	0.54	0.19
Steel on steel	0.30	0.20

Perhaps the most significant use of chromium for improved bearing and wear resistance has resulted from the development of porous chromium. This is produced by subjecting hard chromium deposits to a short anodic treatment after cathodic deposition to widen the fine microscopic cracks in the surface. The microscopic cracks and fissures aid in retention of lubricating oils at bearing surfaces, and a marked increase in the life of cylinder bores, liners and piston rings of internal

(Continued on p. 190)

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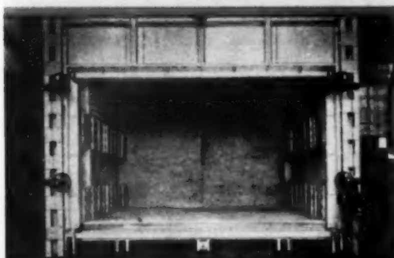

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Properties of Electroplates

(Begins on p. 182)

combustion engines has resulted from the use of this electrodeposit.

During the recent years, it has become possible to apply metallic coatings to nonconductors by electrodeposition. This has opened a wide field of possibilities, particularly in the electrical, radio and electronics industries. It has also been used for decorative effects.

Electroforming, the production of intricate shapes by electrodeposition, is described in general terms and some instances given, such as Pitot static tubes. The importance of this application of plating (sometimes called "cold casting") is properly emphasized.

ADOLPH BREGMAN

Fatigue Resistance of Heat Treated Aluminum and Beryllium Bronzes*

ALUMINUM BRONZE (90.62 Cu, 9.27 Al, 0.07 Fe and 0.09% Zn) and beryllium bronze (97.26 Cu, 2.25 Be, 0.30 Ni and 0.10% Fe) were subject to fatigue and fatigue-corrosion tests in these heat treated conditions:

Aluminum Bronze

1. Heated 1 hr. at 1620° F., quenched in water.
2. Treated as in 1 then reheated 1 hr. at 1110° F., air-cooled.

Beryllium Bronze

1. Heated 40 min. at 1490 to 1510° F., quenched in cold water.
2. Treated as in 1 then reheated 1 hr. at 680° F., quenched in cold water.

The fatigue and corrosion-fatigue tests were carried out in rotating-beam machines. A fine mist of 3% salt solution was sprayed on the corrosion-fatigue specimens during the test.

The results of fatigue tests in air indicate that the fatigue limit, particularly in the aluminum bronze, is not reached at an endurance of 50 million cycles, and the values have therefore been recorded as endurance limits on that basis. The endurance limits for the present aluminum bronze in the heat treated conditions (about 25,700 psi. in the quenched

(Continued on p. 192)

*Abstract of "The Resistance of Aluminum and Beryllium Bronzes to Fatigue and Corrosion Fatigue", by D. G. Sopwith, Reports and Memoranda No. 2486, Aeronautical Research Council.

Fatigue Resistance of Heat Treated Aluminum and Beryllium Bronzes

(Continued from p. 190)

and 22,400 psi. in the quenched and reheated condition) are considerably lower than of the previous (8.9% Al) aluminum bronze tested in the as-received condition (extruded and drawn, 31,900 psi.), although there is little difference in the ultimate stresses.

The fatigue test results in air on the beryllium bronze are interesting. Normally, the effect of heat treatment on a material tested in the polished condition is to increase its fatigue strength almost in proportion to its ultimate tensile stress, the endurance ratio (ratio of fatigue limit to ultimate stress) decreasing slightly as the ultimate stress increases. In the beryllium bronze, however, there is little variation in fatigue strength (36,400 to 43,700 psi.) for a wide variation in ultimate stress from 71,700 to 181,500 psi. There is thus a very marked decrease in endurance ratio as the ultimate stress increases. A notch-sensitive material would be expected to behave in this way when a high degree of stress concentration is present, due to a sharp change of form. The reason in the present case may be similar, due to internal stress or to flaws set up during the heat treatment. No indication was observed of the presence of such flaws. The value of 0.54 for the endurance ratio of this material in the soft state is exceptionally high for a nonferrous metal.

The logarithmically plotted stress-endurance curves for the corrosion-fatigue tests are, in the case of the aluminum bronze in both conditions and the beryllium bronze in the quenched condition, straight lines, with some very slight initial curvature at endurances below about 2 million for the quenched and reheated aluminum bronze. This agrees with all previous corrosion-fatigue tests conducted at the National Physical Laboratory. The results on the quenched and reheated beryllium bronze show some scatter, but are probably adequately represented by a curve which shows a fairly pronounced curvature up to about 10 million cycles. In neither of the two materials did heat treatment (either quenching alone, or quenching and reheating) give a corrosion-fatigue endurance limit as high as that of the material in the as-received (extruded and drawn) condition.

(Continued on p. 194)

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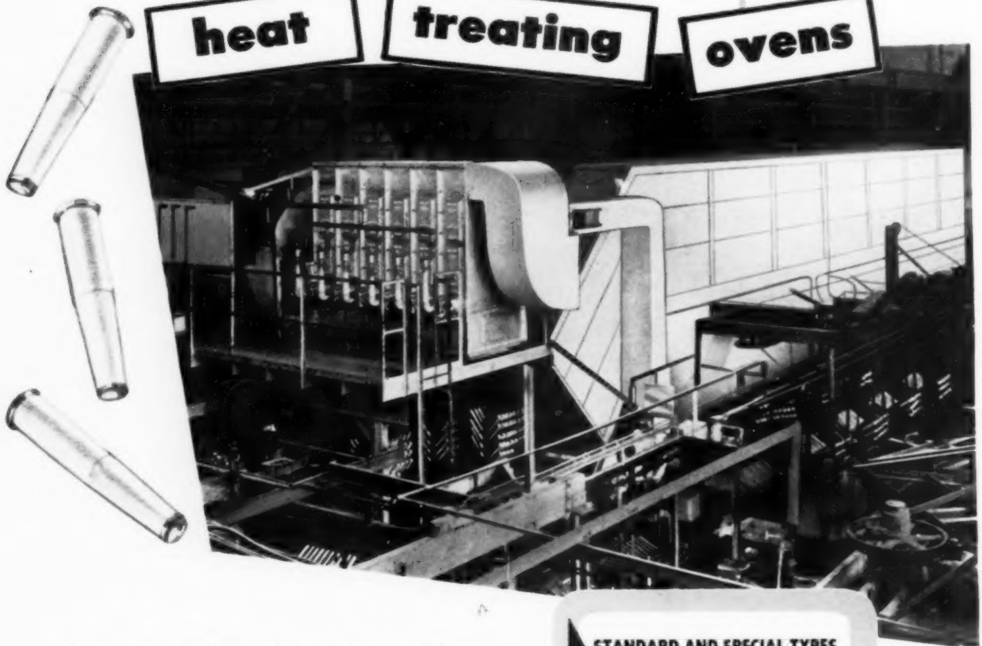

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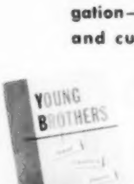

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Fatigue Resistance of Heat Treated Aluminum and Beryllium Bronzes

(Continued from p. 192)

The endurance ratio of aluminum bronze does not vary much with heat treatment over the small range of ultimate stress covered; that of the beryllium bronze, however, as in tests in air, varies widely. In the two heat treated conditions, the endurance limit in salt spray is about 80% of that in air, the extruded and drawn condition giving a value 7% higher than that in air. The small effect of heat treatment on the corrosion-fatigue resistance is to be expected as the latter is affected more by composition and internal stress than by the ultimate stress or air fatigue limit. In this case, moreover, as pointed out above, the fatigue limit in air also was almost independent of heat treatment.

Centrifugal Method of Testing at High Temperatures*

PRESENT methods of testing high-temperature strength, such as creep and rupture tests, require complex apparatus, long testing times, and are limited to a maximum temperature of 1470 to 1560° F. Because of the complexity of classical creep testing methods, substitutes have been proposed. One of these involves the sagging of wires, either under their own weight or under an external load. Bochvar, in 1947, proposed testing the change in hardness and showed that this placed aluminum alloys in the same order of merit as did creep testing. However, this method is limited to tests at 1380 to 1490° F. Oding suggested a split-ring specimen that permits testing simultaneously 20 specimens and magnifies the deformation 2000 times. Kornilov, in 1941, used wire or strip specimens mounted as cantilever beams so that they bent under their own weight at elevated temperatures. This bending occurred at 1830° F. (for alloy steels); however, at lower temperatures it was

(Continued on p. 198)

*Abstracted from "Centrifugal Method of Testing the Strength of Metals and Alloys at High Temperatures", by I. I. Kornilov, *Zavodskaya Laboratoriya*, 1949, p. 76-82; and "The Centrifugal Method of Testing Metals and Alloys at High Temperatures", by M. E. Rabinovich, *Zavodskaya Laboratoriya*, 1949, p. 988-993.

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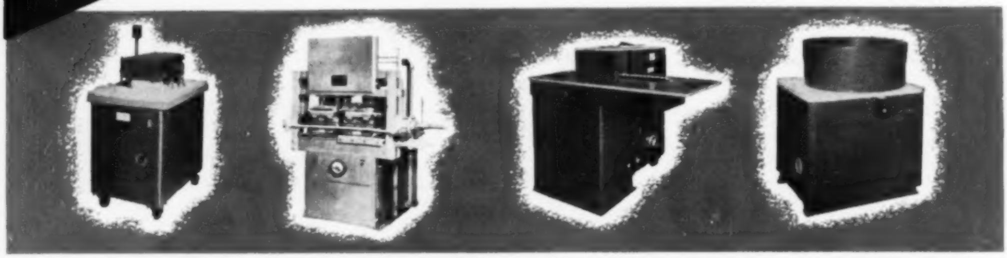

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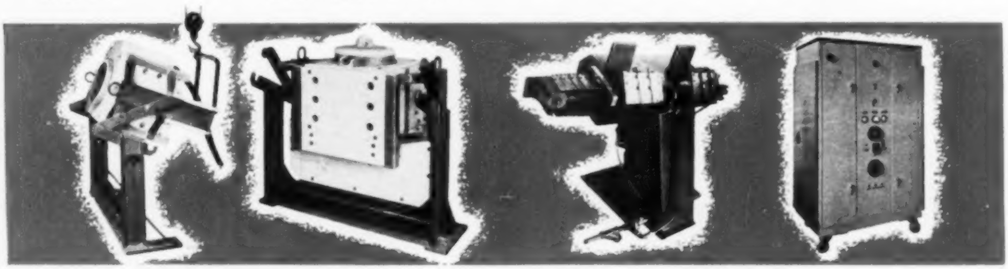

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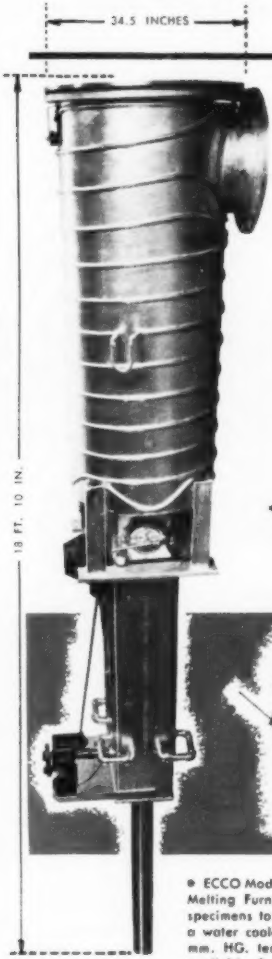

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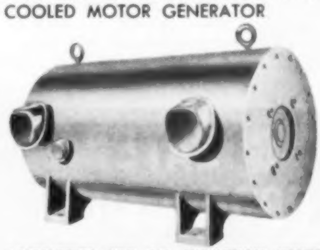

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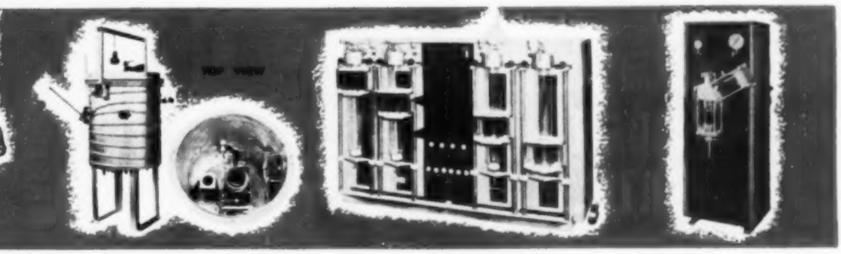

● ECCO Model F66B Coil Tilting Type High Vacuum Melting Furnace with provisions to add alloying specimens to the charge and pour the metal into a water cooled mold. Operating pressure 10^{-4} mm. HG. temperature 2000° C+. Unit capacity available from 30 to several hundred pounds.

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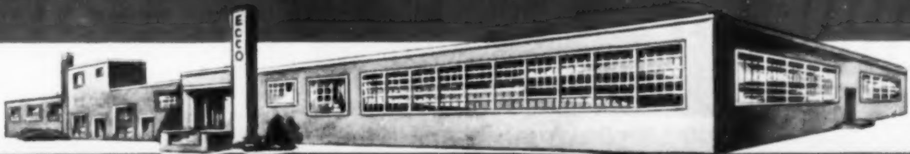

MANUFACTURERS OF INDUSTRIAL HIGH FREQUENCY HEATING EQUIPMENT

Testing at High Temperatures

(Continued from p. 194)

necessary to use several hundred gram loads at the ends of the specimens, and it was difficult to design suitable apparatus.

The centrifugal method of testing alloys is based on the deformation of the specimens at high temperatures under the continuous action of centrifugal force. This force can be applied to cause bending or tensile elongation, and it can be used to study creep. The method of investigating deformation in bending is most practical since no complicated equipment is required and a large number of small specimens can be tested simultaneously. Tension testing is also relatively easy by the centrifugal method, and in certain temperature ranges the creep behavior of a large number of specimens can be studied simultaneously. Machines for both types of testing were built.

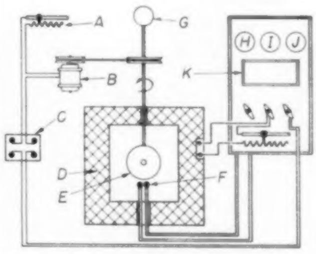

Fig. 1 — Centrifugal Equipment for Testing High-Temperature Strength

The machine for testing specimens in bending is shown schematically in Fig. 1. Specimens were held at one end in a fixture attached to the lower end of the rotating shaft. Initially, the axes of the rod specimens were vertical, but the centrifugal force tended to cause them to bend outward toward the furnace walls.

Resistance to bending was measured in degrees of the angle of bend or in millimeters of displacement. The speed of rotation was varied by means of a rheostat; constant speed was insured by a voltage stabilizer. Cylindrical specimens 3, 4, 5 and more millimeters in diameter were tested in groups of 12, 24 or more. The specimens weighed 5 to 10 g. and were easily prepared in the cast or wrought condition.

By taking periodic deformation readings it was possible to con-

(Continued on p. 202)

1950 Metal Show, Chicago: transmission hubs

1949 Metal Show, Cleveland: wrench jaws

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Five years ago Flamatic selective surface hardening was demonstrated for the first time—in production—at the Metal Show in Chicago and made front-page news as an important new tool for industry. At each succeeding Metal Show, Flamatic was shown in production on difficult heat treat jobs. Once again we invite you to—

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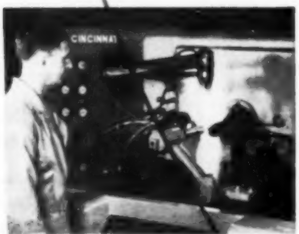
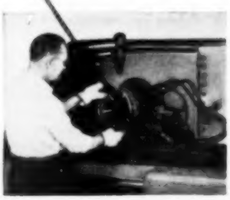


1948 Metal Show, Philadelphia: drive shafts

visit booth G-356
metal show: detroit
october 15-19



1947 Metal Show, Chicago: ring gears

flamatic

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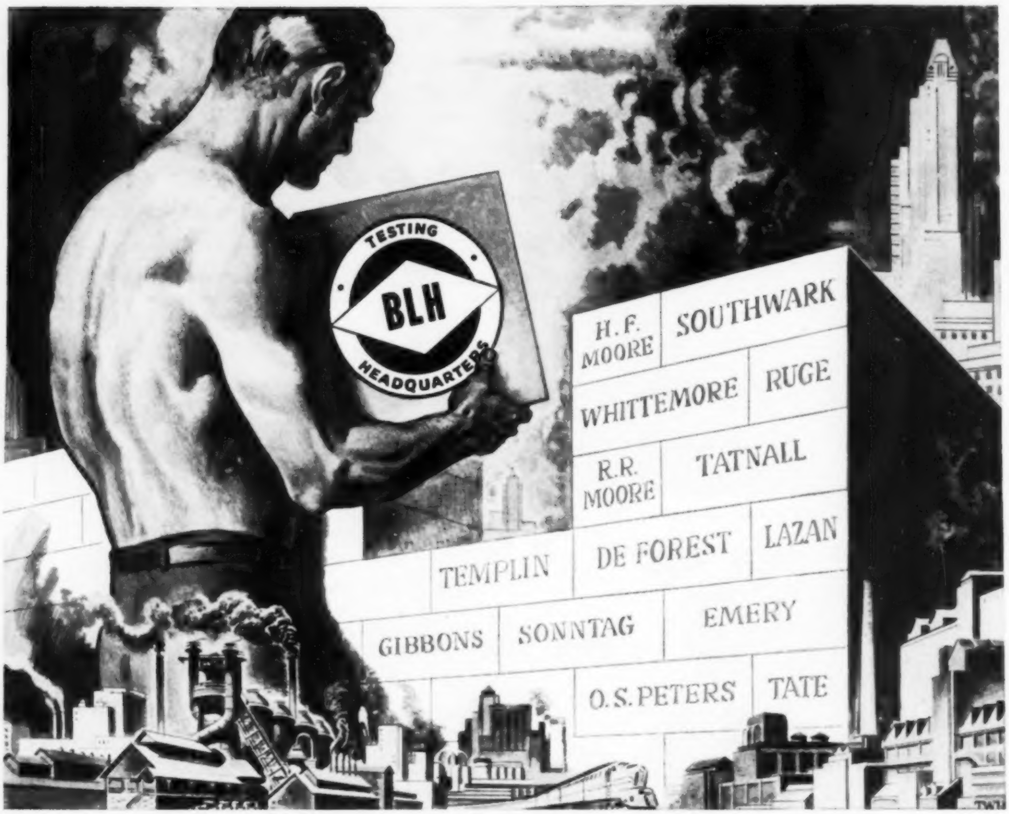

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Testing at High Temperatures

(Continued from p. 198)

struct curves of deformation versus time for various materials. These curves showed a slightly increasing rate of deformation with increasing time until the constant, maximum deformation was nearly reached. Because the stronger specimens showed no bending during the first several hours, a possible measure of high-temperature strength would be the time necessary to cause bending to begin.

There is a definite advantage in using initial bending as a strength criterion since the bending force increases as bending proceeds and reaches a maximum at 40 to 45°. Possible quantitative measures of the strength of various alloys are: *(a)* Time necessary for initial plastic deformation at a given stress, *(b)* initial velocity of deformation, *(c)* time necessary for a given amount of deformation, *(d)* time necessary for maximum deformation.

Tests were run on ferrous high-temperature alloys using specimens 0.158 in. in diameter and 3.94 in. long, a temperature of 1830° F., and a speed of 1500 r.p.m. A ferritic chromium-aluminum alloy (EI 340) bent almost 90° in 15 min., two austenitic alloys (EI 69 and EI 310) bent about 60° in 2.5 hr., Timken alloy bent about 40° in 10 hr., and Vitallium bent only 3° in 160 hr.

Tests were run at 570° F. on a series of aluminum-magnesium alloys containing from 0 to 12% magnesium after these alloys had been slowly cooled from a four-hour treatment at 750° F. The strength increased with increasing magnesium content up to the limit of solid solubility and then rapidly decreased to the lowest values at 10 and 12% magnesium.

Alloys containing up to 50% chromium of the 3:1 iron-nickel section of the iron-nickel-chromium diagram were studied at 1420° F. Again the alloy containing the maximum amount of chromium (about 25%) without the appearance of a second phase showed the highest strength.

There are two methods of reducing the time needed to determine the high-temperature strength of alloys. First, the time needed for each test can be reduced. Second, the number of specimens that can be tested at one time can be increased. An example of the first

(Continued on p. 204)

Testing at High Temperatures

(Begins on p. 194)

procedure is the use of the impression produced by an indenter as a qualitative measure of creep. This method requires only four hours, but it is limited to relatively low temperatures. Other short-time creep testing methods are known, but all of them become less reliable as the time of testing is decreased. Also, it is difficult to evaluate the effect of phase changes or recrystallization. Finally, high stresses must be used in these short-time tests, while much lower stresses are used in practice.

The centrifugal force method of Kornilov gives an opportunity of utilizing the second alternative, increasing the number of specimens tested at one time in a given machine. This method was one of those used in investigating the high-temperature strength of aluminum-copper-magnesium-zinc alloys. Specimens of the 16 compositions were prepared in rod form and were stabilized by a 200-hr. treatment at 570° F. following quenching and aging.

All of the tests were carried out at 570° F. The specimens were 0.158 in. in diameter and 3.94 in. long, and 12 specimens were run simultaneously. A fiber stress of 1400 psi. was produced by the speed of rotation which was 1500 r.p.m. The criterion of high-temperature strength was the time necessary for the amount of bending to reach 0.079 in. A plot of this quantity versus composition is shown in Fig. 2.

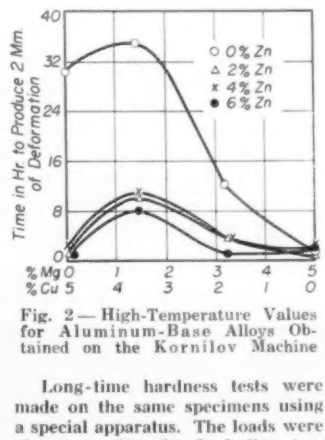

Fig. 2 — High-Temperature Values for Aluminum-Base Alloys Obtained on the Kornilov Machine

Long-time hardness tests were made on the same specimens using a special apparatus. The loads were chosen so that the final diameters were within the limits 0.35 d. and

Testing at High Temperatures

0.6 d., where d. is the 0.197-in. diameter of the steel balls used. The loads were applied for 50 min., and the hardness was determined by the Brinell formula. Effect of composition on the hardness of aluminum-copper-magnesium alloys is shown in Fig. 3.

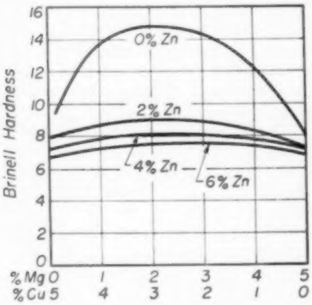

Fig. 3 — Hardness Values for Aluminum-Base Alloys Using a 50-Min. Testing Time

Ordinary creep tests were run on the specimens containing 1.6% Mg, 3.4% Cu, and from 0 to 6% Zn. The measure of creep strength used was the deformation produced in 100 hr. by a stress of 1400 psi. These results are shown in Fig. 4.

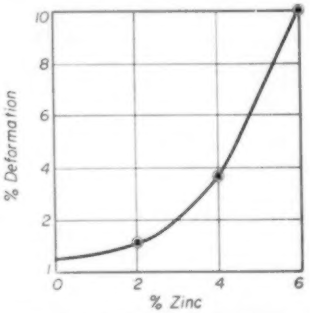

Fig. 4 — Deformation of Aluminum-Base Alloys (1.6% Mg, 3.4% Cu and Zinc) Produced by a 1400-Psi. Load Applied 100 Hr.

A comparison of the results of the centrifugal method and of the long-time hardness method shows that they give the same qualitative rating of the high-temperature strengths of a group of alloys. In this instance the aluminum-copper-magnesium alloys have the best high-temperature strengths, with a maximum lying on the line joining

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Testing at High Temperatures

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aluminum and the "S" phase. The creep results are also in good agreement with those obtained by the centrifugal method.

A mathematical analysis of the bending force on the specimen in the centrifugal method showed that the bending force reaches a maximum value 2.835 times the initial force at an angle of bending of 40°. This increasing bending force explains why this method is more sensitive than the long-time hardness test.

It is proposed that additional work be done to determine the relation between velocity of deformation and the amount of deformation. Also, emphasis is made of the undesirability of interrupting the test to take deformation readings.

A. G. Guy

Oxygen Cutting*

A characteristic of oxygen cutting is the drag line. Drag, the distance measured parallel to the surface between the top and bottom of the cut, is explained as the resultant of three velocities: *(a)* the speed of advance of the torch, *(b)* the speed of oxidation, *(c)* the actual cutting speed. The relationship of these three factors of drag is shown in Fig. 1 and 2. The width and depth

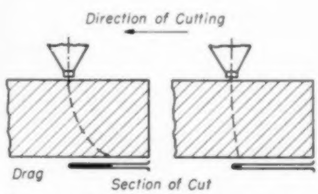

Fig. 1 — Diagrams Showing Formation of Drag Lines. (Left) Large drag results when cutting speed is too high or oxygen supply too small. (Right) Normal drag is obtained using correct speed and oxygen supply

of drag lines depend a great deal on cutting conditions. In manual cutting, the irregularities inherent in hand guidance result in deep drag lines while machine cutting produces thin, regular drag lines. High-speed motion photography was se-

(Continued on p. 208)

*Abstracted from a translation of "New Data on the Oxygen Cutting of Steel", by F. Pfleiderer, *Journal de la Soudure*, Vol. 38, 1948, p. 151-160.

Oxygen Cutting

(Continued from p. 206)

lected as the best means of obtaining information on the cutting action.

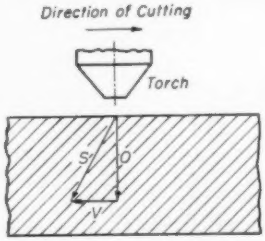

Fig. 2 — Vector Diagram of Drag Lines. V = speed of advance of torch; O = velocity of oxidation; S = actual cutting speed

The purpose of the research was to secure a more exact understanding of the nature of oxygen cutting and to understand the origin of drag lines in the hope of improving the smoothness of oxygen-cut surfaces. The high-speed cinematography was done in the Zeiss plant with a camera capable of taking as many as 3000 frames per sec. The plate to be cut was mounted on the cross-head of a lathe so that the torch could be held stationary and in focus. The cuts were made along the edge of the plate for convenience in viewing. The pictures were taken on 35-mm. color film with very high intensity lighting supplementing the illumination provided by the cutting torch.

The film shows that the process of oxygen cutting is a completely continuous one; if oxygen supply and rate of advance of the torch were absolutely uniform, the cut would be perfectly smooth. Slag plays an important part in cutting, the progress of combustion through the thickness of the plate being aided by the heat of combustion itself and the heat in the molten slag. Without the heat from the slag, cutting would be impossible, because the hottest part of the preheating flame is only a few millimeters ahead of the tip of the inner cone and it cannot furnish enough heat to the deeper parts of the cut. This seems particularly true in the cutting of very thick sections where the required preheat is furnished principally by the slag.

The origin of gouges in the surface of a cut made at too slow a speed is explained by the cutting jet finding more favorable points of attack on the sides of the cut when its speed of advance becomes too

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Oxygen Cutting

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great. The jet progresses in this new direction until it finds new material on the forward surface of the jet, over which the slag can flow.

In the removal of the molten material (iron and iron oxide) from the cut, it was observed that part of the material was driven down the sides of the cut and blown out by the oxygen jet, the remainder being rejected in back of the cutting jet. The molten material becomes visible back of the cutting jet only a certain distance below the surface of the plate. The zone at the upper edge of a smooth cut where no drag lines are in evidence is the zone that shows no molten material back of the jet.

The high surface tension of the slag is believed to be the main reason for the formation of drag lines. The movies revealed a periodic breaking loose of molten material from the jet each time the supply of molten material from the front of the cut was exhausted.

The author's conclusions are:

1. The jet moves continuously in the direction of cutting, with no lateral deviations.

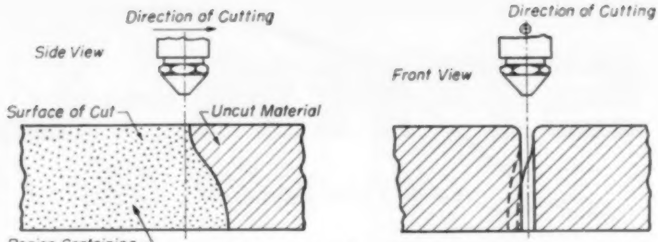

Fig. 3 — When Speed of Advance Is Too Slow, Jet Attacks Side Walls Until New Material Comes to Front Surface of Jet

2. The cutting jet has no gyratory motion.

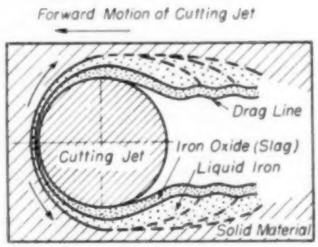

Fig. 4 — Molten Material Formed in the Cut Is Rejected to Rear Where It Forms Drops Which Rapidly Solidify

3. Good combustion is shown by the presence of slag which acts to preheat the metal.

4. If the cutting speed is too slow, the jet attacks the side walls of the cut instead of the front wall until the torch has advanced sufficiently to bring new material to the front surface of the jet.

5. Most of the molten material formed in the cut is rejected to the rear where, by reason of its high surface tension, it forms drops which freeze rapidly. The small depressions formed between overlapping drops constitute the drag lines.

S. Feigenbaum

Explosion Deformation Tests of Weldments*

In the Naval Research Laboratory bulge tests of full butt welded joints, loading was applied by an explosive charge — using a standard military demolition explosive — in the shape of a wafer located 12 to 24 in. above the test plate. This explosive can be readily shaped to a circular or elliptical wafer of desired size.

The test weldment consisted of a 20 x 22-in. plate produced by butt welding two 10-in. wide plates. For testing, the weldment was placed over either a circular (6-in. radius) or elliptical (radii of 7.5 and 4.8 in.) opening cut in 4-in. thick armor plate. The die opening was chamfered to facilitate entry of the bulge into the die cavity. The explosive wafer, supported above the plate by a cardboard box, was electrically detonated. Unsupported area of the weldment was approximately 28% of the total area. It was found that the size of the bulge could be closely controlled by varying the weight of charge and amount of standoff.

Information was obtained regarding the nature of plastic deformation of welded joints with matching and overmatching weld metals. Both balanced and unbalanced stress fields were included. With the unbalanced stress fields, weld orientations were varied with reference to the direction of major stress. All strain measurements were made at arbitrary levels well below the critical strain-producing fracture.

Material used was ¾-in. thick, silicon-killed firebox steel plate. Butt joints were of two types: a single-pass submerged arc weld of square geometry and a manual multipass double-V weld of geometry similar to that used in ship construction. The submerged arc weld metals were a low carbon, 2% manganese, and a composition similar to S.A.E. 6130. Manual welds were made with an E12016 electrode. Tests also were made on prime plate to provide a reference basis for comparison.

The low-alloy submerged arc weldments were tested under three conditions:

(Continued on p. 214)

*Abstract of "Explosion Bulge Test Studies of the Deformation of Weldments", by C. E. Hartbower and W. S. Pellini, *Welding Research Supplement*, Vol. 16, June 1951, p. 307s-317s.

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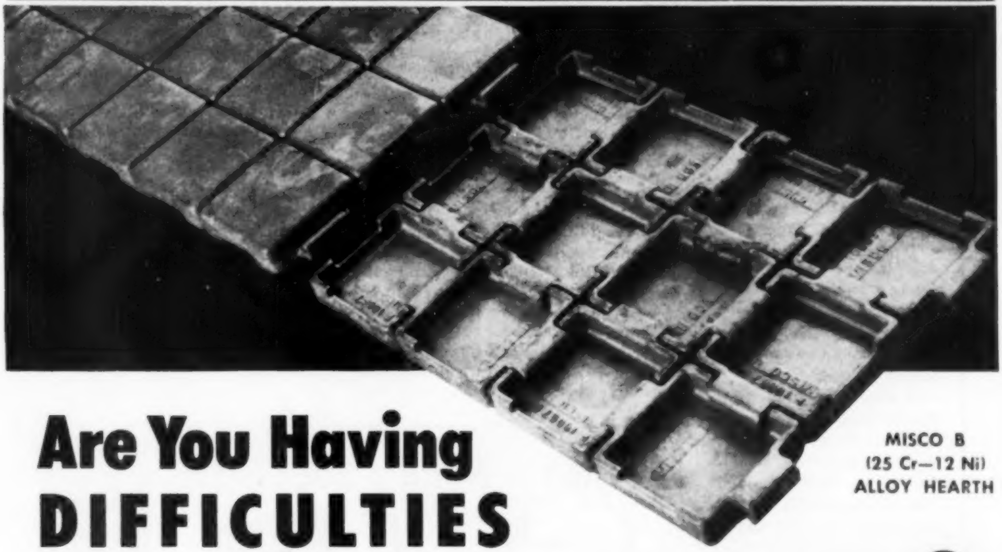

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Explosion Deformation Tests of Weldments

(Continued from p. 212)

1. Balanced biaxial stress (circular die).

2. Unbalanced biaxial stress (elliptical die) *(a)* with weld perpendicular to major principal stress (coincident with major axis of die) and *(b)* with weld parallel to major principal stress (coincident with minor axis of die).

These weldments represent fairly close matching of weld metal and plate flow strengths. In the circular bulge, the presence of the weld produced an unbalanced strain pattern, with the major stress occurring longitudinally in the weld direction. In all cases the strain transverse to the weld is decreased from that observed in the same locations of the unwelded bulge. In the elliptical bulge the strain longitudinally in the direction of the weld is not significantly different from that observed in the unwelded bulge in the same location and direction.

The high-alloy submerged arc (tested with the elliptical die only) welds overmatch the plate by about 43,000 psi. in flow strength. With the weld on the major axis of the die, the strain field of the bulge was completely reversed from that of the unwelded bulge (from 1 to 2 to approximately 3 to 1). With the weld on the minor axis of the die, the strain field of the bulge showed an unbalanced ratio markedly increased (1 to 8) from that of the unwelded bulge (1 to 2). While exact comparisons between the low and high-strength weld metal bulges cannot be made, because of the testing differences, it is interesting to note that the higher strength weld metal caused a greater reduction of strain transverse to the joint from that in the unwelded bulge.

The manual E12016 weldments were tested only with the elliptical die as indicated by 2a and 2b. These weldments represent considerable overmatching of the plate by some 66,000 psi. in flow strength. With the weld on the major axis of the die, the strain field of the bulge indicated a 1 to 1 ratio as compared with a 1 to 2 ratio for the unwelded bulge. With the weld on the minor axis of the die the strain ratio was 1 to 7 as compared with the strain ratio of 1 to 2 for the unwelded

(Continued on p. 216)

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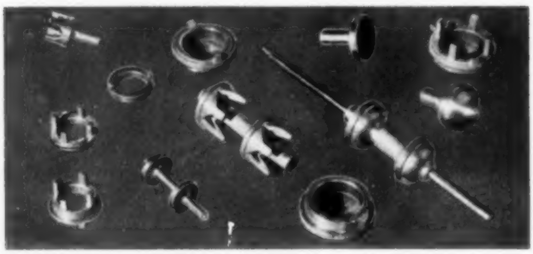

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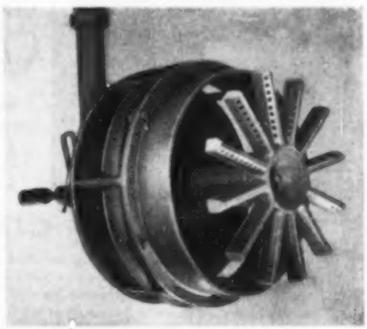

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Explosion Deformation Tests of Weldments

(Continued from p. 214)

bulge. In both cases the strain along the weld was not significantly different from that of the unwelded bulge in the same location and direction.

Transweld strain reductions were less for the manual weld than for the high-strength submerged arc weld, particularly in view of the fact that the manual multipass single-V weld overmatched the plate in flow strength to such a greater extent than the single-pass high-strength submerged arc weld of square geometry. It is suggested by the authors that this behavior may be accounted for by the difference in geometry of the welded joints.

From the test data the authors deduce that:

1. With overmatching welds in unbalanced biaxial load fields the principal strain reaches *(a)* a maximum value when the weld is located in the direction of the major stress, and this strain is always along the length of the weld regardless of overmatching characteristics and joint geometry; *(b)* a minimum value when the weld is located in the direction of the minor stress.

2. With overmatching welds in unbalanced biaxial load fields, the direction of the minimum principal strain varies with overmatching characteristics. Ordinarily, this strain is transverse to the weld but shifts to the longitudinal direction if overmatching characteristics and joint geometry produce sufficient deconcentration to reverse the strain field.

3. Overmatching welds in balanced biaxial load fields will develop highly unbalanced biaxial stress patterns.

The authors also point out that "For uniaxial or strongly unbalanced biaxial loads, it is possible to reduce the value of the principal strain by orienting the weld transverse to the direction of principal load. In the case of balanced loads such manipulation is not possible."

In view of the above data and the deductions offered, it is perhaps unfortunate from the viewpoint of the welding engineer that the undermatching weld is not included. However, there is a very significant possibility, as suggested by the authors, that geometry of the weld may be of greater influence on the stress or strain patterns than overmatching characteristics.

W. L. Warner

Steel in India

(Starts on p. 93)

major iron and steel producers, the deposits in Orissa and Madhya Pradesh are important. The former are within 110 to 200 miles from the major producers and the latter about 550 miles away. Ores are generally of medium phosphorus content, but as there is very little low-phosphorus coking coal, Indian ferromanganese is higher in phosphorus than the foreign product.

Though very little effort has so far been made to estimate the size of Indian manganese deposits, it can be safely said that they are sufficient for internal consumption with a moderate exportable surplus.

CHROMITE

Chromite is used as an alloying element as well as a refractory. High-grade ores are used for the former, since ferrochromium is not manufactured in India at present. Chromite is being mined at Nuasahi in Orissa State, Chaibassa in Bihar, and in Mysore. The Chaibassa deposits, the nearest to the steel plants, are in an open pit which has now reached an uneconomic stage of working. Location of extensions of old lodes and new lodes by geophysical prospecting and diamond drilling is necessary.

The Orissa deposit is the richest in quality of the ore so far found in the Indian Union. Unfortunately, no attempt has been made to prospect the body or to work it scientifically. The Mysore deposits are close to the Mysore Steel Works and supply all their requirements.

We can safely say that total reserves are extremely limited and their export should be restricted or stopped altogether.

MINOR ALLOYS AND REFRACTORIES

No commercially workable deposits of tungsten, nickel or molybdenum have been found, and the present consumption is so small that any mining would have to depend on exports. Vanadium (2.5% V_2O_5) is found associated with titanium in extensive iron ore deposits in the states of Bihar and Orissa; considerable experimental work has been done on the concentration of these ores.

While India is favorably endowed

(Continued on p. 220)

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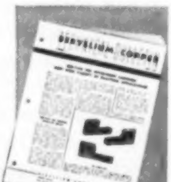

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Steel in India

(Starts on p. 93)

with fireclays, and the best are associated with coal measures, production to close specification has never been attempted.

Summarizing the situation in raw materials, and keeping in view an expansion of the industry, India has a marginable surplus of iron and manganese ores for export. We should try to estimate the reserves of our manganese ores and fix the export quota, but we can easily work some very large iron deposits for export only. In the distant future, even if we manufacture 25,000,000 tons of steel per year, our consumption of iron ore will be about 50,000,000 tons and of manganese ore 1,200,000 tons. Our resources in these two are ample for an indefinite time. However, attention must be paid to cheap bulk mining, and the preparation and standardization of raw materials.

FUTURE OF INDIAN STEEL INDUSTRY

The great disparity in the reserves of high-grade iron ores and coking coals puts a limitation to the production of iron in blast furnaces. Consequently, the pattern of the future iron and steel industry in India will be different from that in any other country. Near the coal fields, until the reserves of coking coal are exhausted, we will have to run ordinary blast furnaces. Where cheap electricity is available, we will have to use the Tysland-Hole electric furnace. (The first one of its kind is nearing completion at Mysore.) We should also try the Krupp-Renn, Stuerzelberger* and low shaft furnaces which do not require coking coal, since we have reasonable reserves of noncoking coal. It may also be advisable to set up small units for the production of charcoal pig for high-class steels.

The use of the different processes will depend on the regional advantages of each. A balanced, over-all planning, keeping in view stark realities, will be necessary to make the best use of our resources.

The Government of India had planned to build two integrated steel plants of 500,000 tons capacity in the postwar industrialization

(Continued on p. 222)

*The Krupp-Renn process reduces a mixture of fine ore and coal in a rotating furnace like a cement kiln. The Stuerzelberger furnace is similar in principle, but its axis is not fixed; operating as a batch-type process the furnace can be tilted to any safe angle for charging or discharging.

Steel in India

(Continued from p. 220)

scheme. Each of the plants was estimated to cost about 1000 million rupees ($210,000,000). However, the Government, with its high commitments on the river valley projects, did not make the necessary appropriations and, as outside capital was not available, these plans have been shelved temporarily. This "steel plan" intended to nationalize this basic industry after running the newly built plants for a decade. The industry in this country is already controlled, in a way, since the wartime Iron and Steel Control has become a permanent feature, wherein the selling price of steel and its distribution are controlled by the Government. Discussions on this subject have so far been conducted in very general terms, and have not come down to the specific point of the degree of benefit to be derived from such capital expenditures and nationalization.

At present the Government is loaning money to the three major operators to renovate and expand their facilities. The over-all increase in steel production will be about 400,000 to 500,000 tons per annum (about one third present capacity).

In conclusion it may be said that the prospects of our iron and steel industry are very encouraging. India has great future economic possibilities, an abundance of raw materials, huge population, and potential markets. Even the limited reserves of coking coal need not worry us if properly utilized. The Government has been committed to a policy of industrialization and the fundamental importance of such a basic and important industry cannot be overemphasized.

India is singularly well placed to support an integrated industry. While Europe as a whole is self-sufficient in coal and scrap, and largely though not entirely independent as regards iron ore, individual countries are in a different position; the striking feature is their interdependence for the principal raw materials.

Consequently, future expansion in India must face two special difficulties. The first is our complete dependence on the western countries for capital goods. The second is the problem of finance. That we can overcome both these difficulties will depend on how much free enterprise is allowed to play its part in future developments, our fiscal policy, the cooperation of labor,

(Ends on p. 224)

and a deep study of all factors for the future industrialization of the country.

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on Aluminum Bearings

(Starts on p. 97)

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Gaseous Annealing of Black-Heart Malleable Iron*

GASEOUS ANNEALING of black-heart malleable iron in controlled atmospheres is easily and conveniently done in furnaces well sealed to prevent infiltration of air or flue gases. A suitable atmosphere soon results from the interaction of the carbon in the castings and the residual air. Poor furnace seals lead to badly decarburized and pearlitic rims in the annealed castings. If additional atmosphere is deemed necessary, it must not contain more than 3% H_2 and very little water vapor, since hydrogen in greater amounts will retard the graphitizing reaction.

For British irons of 2.30 to 2.50% C and 0.90 to 1.10% Si, a typical annealing cycle for black-heart malleable might be 40 to 70 hr. divided as follows: *(a)* Heating up to top soaking temperature for 9 to 12 hr. (slow heating between 700 and 1100° F. to induce maximum nodule number for accelerated graphitizing rate); *(b)* Primary graphitization of massive carbide at 1650 to 1700° F. for 15 to 30 hr.; *(c)* Cooling to just above critical range (1400° F.) at 100° F. per hr. for 3 to 5 hr.; *(d)* Slow controlled cooling to effect secondary graphitization through and below critical range (1400 to 1300° F.) at 4 to 9° F. per hr. for 12 to 24 hr.; *(e)* Final cooling to room temperature, rate not important.

Furnaces for Gaseous Annealing — No matter what type of furnace is used, it must be sealed against uncontrolled entry of air or flue gases. This can be achieved in practice on large furnaces only by the use of electric resistor units or radiant heating tubes, the particular choice being made largely on the basis of over-all economy.

Continuous furnaces for black-heart annealing are usually straight through tunnel-type, with the length subdivided into the different temperature zones required to effect the proper time-temperature cycle. The work is carried through on a suitable conveyer, of which the pusher-tray type is the simplest and of lowest first cost. Continuous furnaces are most adapted to large tonnages of a constant product, are less flexible for varying load and product than intermittent-type furnaces and so have been little favored by British foundrymen.

Batch-type furnaces that can be easily adapted to gaseous annealing are of four basic types:

1. Horizontal end-charged batch-type loaded with a charging machine.
2. Horizontal car-type hearth.
3. Elevator-type with fixed furnaces mounted above floor level and transportable car-type hearth.
4. Bell or lift-off type with fixed hearth and movable furnace.

The last two types are most easily rendered gas-tight. Castings can be loaded fairly densely in such furnaces, while small castings are usually placed in alloy baskets. Reasonable temperature uniformity is required, especially during the second stage of the graphitizing cycle, which may be obtained by proper subdivision of the heating elements and a programmed temperature cycle.

If electric resistors are used, forced cooling is obtained by means of tubes mounted in the furnace in-

(Continued on p. 228)

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*Abstract of "Gaseous Annealing of Malleable Castings: The Present Position, Part II — Black-Heart Malleable", by P. F. Hancock, *Journal of Research and Development*, British Cast Iron Research Association, Vol. 3, April 1951, p. 913-922.

Gaseous Annealing of Black-Heart Malleable Iron

(Continued from p. 226)

terior through which air is blown during the cooling cycle. With radiant tube furnaces it is necessary to merely shut off the fuel flow and blow air through the tubes.

The bell or lift-off furnace is quite similar in construction and operation to the elevator-type except that the hearths are fixed units at floor level, while the furnace is movable by an overhead crane.

Two-Furnace System — The heating up and soaking period necessary to complete first-stage graphitization is roughly equal to the time required to cool and complete second-stage graphitization. Because of this, it is sometimes economical with elevator or bell-type furnaces to operate them in pairs, with one furnace maintained at high temperature while the other is used for the low-temperature slow cool. Three hearths are required for this method of operating: one hearth heating in the high-temperature furnace, a second cooling in the low-temperature furnace, with a third being unloaded or reloaded.

If the heating up and soaking period is longer than the time required for second-stage graphitization, it is desirable to use the low-temperature furnace for preheating the new charge before it enters the high-temperature furnace.

There are various advantages to be gained from the two-furnace system. Since both furnaces operate at a nearly constant temperature, there is no energy wasted in heating or cooling brickwork (with a possible saving between 10 and 20% in heating energy) and less wear and tear on refractories. Also, each furnace can be particularly adapted to its function. The low-temperature furnace alone need be equipped with a cooling system. Since this furnace never operates above 1400° F., high-speed circulating fans to promote uniformity of heating and cooling may be incorporated. Finally, there is no risk of recarburizing the surface of the castings, since the atmosphere in this low-temperature furnace can never develop a high CO content.

Electric Elevator Furnace Installation — Since, at present, there is no black-heart foundry in Great Britain operating elevator-type furnaces, it is necessary to obtain operating data from a modern American foundry in Ohio. Here six pairs of electric furnaces using the two-furnace cycle anneal up to 100 tons per day of castings ranging in weight from ¾ to 375 lb. New charges are loaded directly into the high-temperature furnace, and upon completion of this stage to the low-temperature furnace.

Over-all annealing cycle will range from 40 to 60 hr. for an iron of 2.40 to 2.50% C and 1.20 to 1.30% Si. Power consumption averages 375 kw-hr. per ton, maintenance costs are very low, and no heating elements or furnace components have required replacement in 4 years. The cost of the expendable alloy baskets which hold the castings during annealing is about $1.00 per ton.

Gas-Fired Bell Furnace Installation — A number of large gas-fired bell furnaces have been in operation at a British black-heart foundry for about a year. These furnaces are heated by vertical radiant tubes and hold about 25 tons of automotive castings which are self stacking. The entire annealing cycle takes place in the same furnace, requiring 85 hr. for an iron of 0.95 to 1.05% Si content.

C. H. Junge

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Today American industry is constantly searching for ways to lighten the unprecedented load on its production facilities. Progressive manufacturers have discovered that magnesium . . . with its combination of lightness, strength and workability . . . is one answer. These characteristics of magnesium can result in simplified design, speedier fabrication and lowered production costs.

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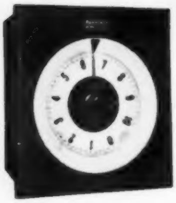
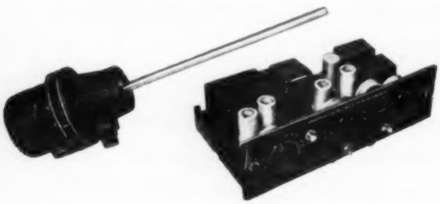
6 things to remember

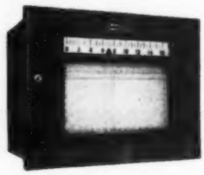
WHEN YOU BUY AN



When you buy instruments, remember these simple facts:

1. Just as insufficient instrumentation is uneconomical, so is instrumentation that is too expensive or too complicated in relation to your furnace or process requirements.
2. Various types and makes of furnaces, and various processes, usually require distinctly different types of instrumentation.
3. No single group of instruments—such as potentiometers, millivoltmeters, thermometers, or non-indicating controls can meet all requirements—any more than can a single type of control action.
4. *Your equipment, your process,* should determine the type and amount of instrumentation you need. Select the instrument or control system that *exactly meets your requirements.*
5. Wherever possible, use instruments that will enable you to centralize responsibility and service with a single source of supply.
6. A careful selection of your instrumentation will pay you increased dividends in lower operating costs and greater efficiency.





Potentiometers	Flow Meters	Excess Temperature Safety Cut-Offs
Millivoltmeter Pyrometers	Liquid Level Meters	Electric Proportioning Relays
Radiation Pyrometers	Remote Transmission Systems	Electric-Pneumatic Relays
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INSTRUMENTATION for a process can be simple or complex. It can involve a few dollars or a considerable investment. Your selection of instrumentation carries not only the responsibility for the operating efficiency of your plant, but also determines whether your investment will be amortized quickly or over a long term.

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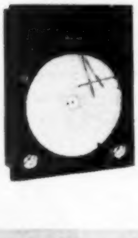
MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4503 Wayne Ave., Philadelphia 44, Pa.



• Description and prices of a number of Brown instruments for metal processing are contained in Catalog No. 51-1 . . . send for your copy today.

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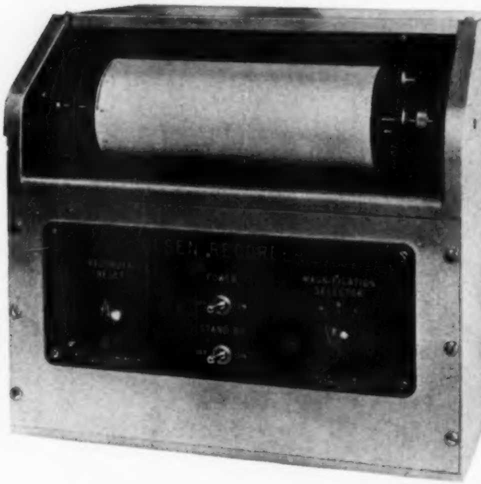
(with alcotran)



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*All Olsen Recorders, Instruments, and Motion Detectors are calibrated to linear standards.

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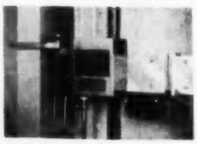

Standard Strain Instrument Type C-1 Deflectometer and Crosshead.

Olsen At The Metal Show Booth D-216

TINIUS OLSEN

Testing & Balancing Machines

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TESTING MACHINE CO.
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"EDCO BOTTOM BOARDS eliminate swelled castings"

Take a tip from E. F. Dublinski. He speaks from experience in saying —"EDCO DOWMETAL Bottom Boards eliminate swelled castings". Since switching to magnesium boards, Mid-City Foundry does not have castings ruined through swelling caused by depressions burned into out-dated wood boards.

EDCO DOWMETAL Bottom Boards help produce castings that are true to pattern. The exclusive grooved and vented design permits escape of gasses, and insures mold stability. Causes for rejects are kept to a minimum.

"We consider EDCO DOWMETAL Bottom Boards as permanent equipment at Mid-City," adds E. F. Dublinski, "because they'll outlast wooden boards at least 30 to 1 and in no time at all pay for themselves."

Your molders will like handling these boards because they are light in weight, easy to stack, and there's no danger of splinters. EDCO DOWMETAL Bottom Boards will not warp or rot—there are no nails to come out, nothing to break or split—no upkeep.

Above photo shows Mid-City Foundry Company molder placing EDCO DOWMETAL Bottom Board on flask preparatory to pressing. Mid-City Foundry produces high quality gray iron and alloy castings.

Write us, or phone CApitol 7-2060 for price schedule and list of 74 standard sizes available from stock.

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Here, you will always find the same painstaking technical service and the same high engineering standards which have characterized the manufacture of Kanthal in Sweden for over 20 years.

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Kanthal Materials Come in Four Types

	MAX. OPERATING TEMP.	OHMS PER CMF	FORMS	APPLICATIONS
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KANTHAL D	**2100° F**	**812**	**Wire, Ribbon, Strip**	Appliances and Furnaces: toasters, irons, and enclosed units as in electric ranges. Outstanding resistance to oxidation.
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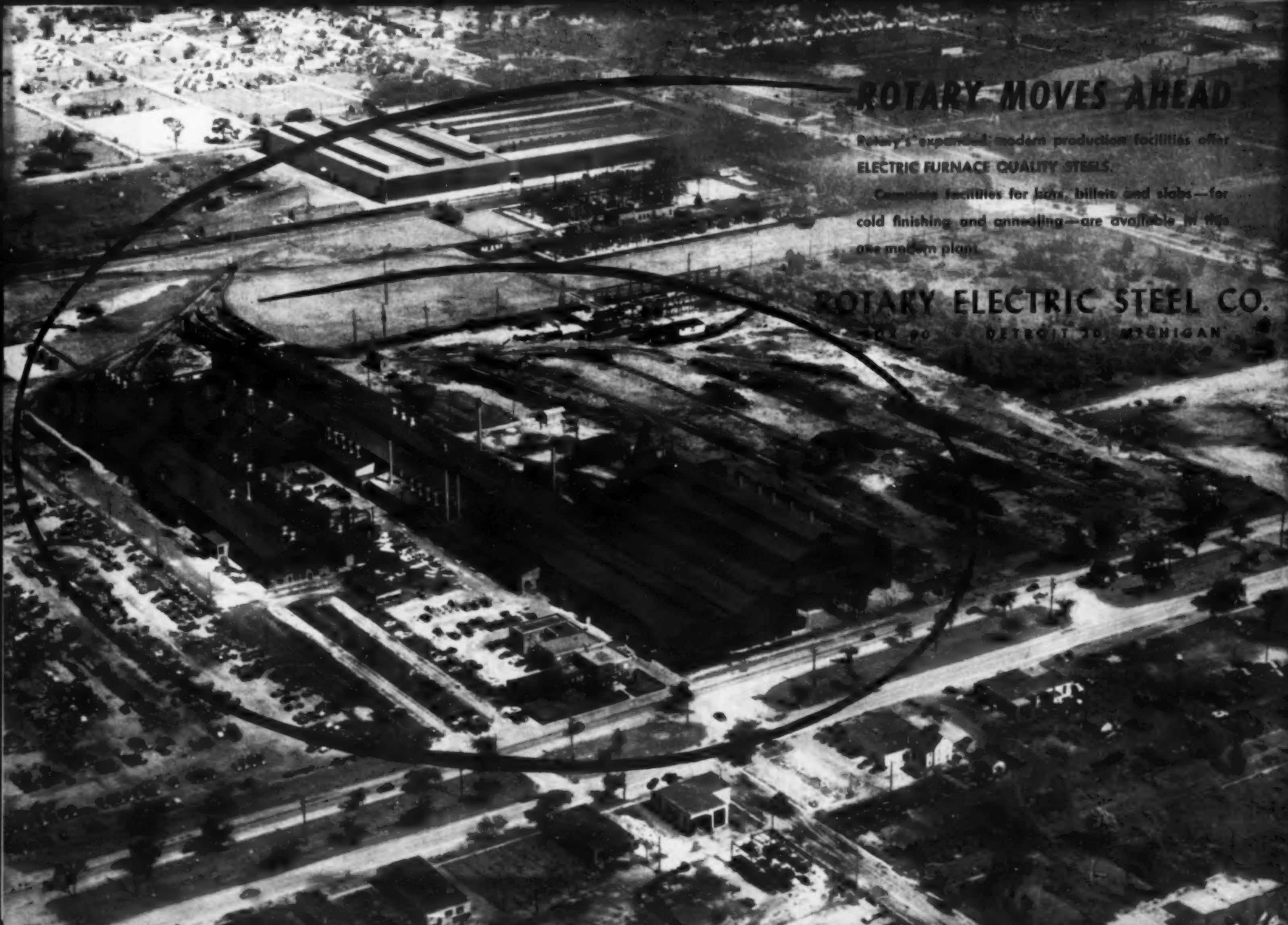
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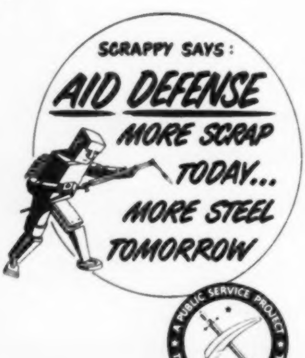
2. Consult with your local Scrap Mobilization Committee about its program to help out in the scrap crisis. The nearest office of the National Production Authority, Department of Commerce, can tell you who your local Scrap Mobilization chairman is.
3. Call in your local scrap dealer to help you work out a practical scrapping program. Non-ferrous scrap needed, too!
4. Write for free booklet, "Top Management: Your Program for Emergency Scrap Recovery", addressing Advertising Council, 25 W. 45th St., N. Y. 19.



FACTS YOU SHOULD KNOW ABOUT STEEL PRODUCTION

Steel production	1950	97,800,000 net tons
Estimated capacity	1952	119,500,000 net tons
Purchased scrap used*	1950	29,500,000 gross tons
Estimated purchased scrap requirement*	1952	36,200,000 gross tons

*All consumers

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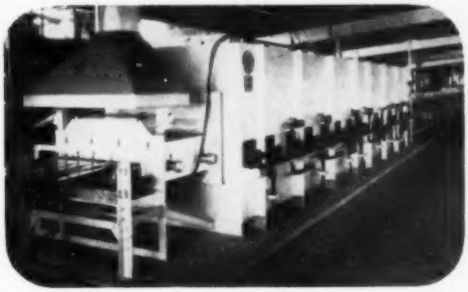
• Index to Advertisers •

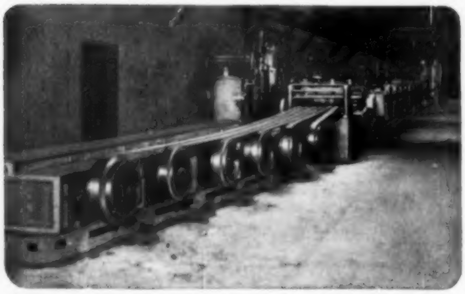
Steel strip in single or multiple strands up to a total width of 54" may be bright annealed or normalized, continuously, in this EF gas fired radiant tube installation. Capacity 7200 lbs. per hour.



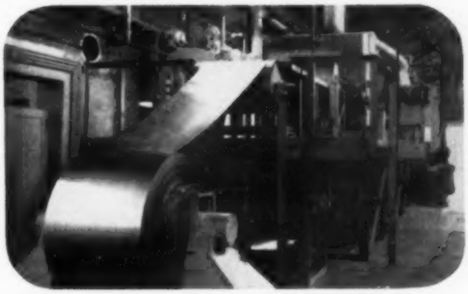
An EF electrically heated special atmosphere installation bright annealing six parallel strands of cold rolled steel strip, continuously. Handles single or multiple strands up to a total width of 30"

CONTINUOUS EF INSTALLATIONS

For Bright Annealing, Normalizing, Galvanizing and Other Continuous Processing of Strip



Another EF gas fired radiant tube, continuous furnace for bright annealing or normalizing cold rolled strip steel. Has preheater or burn-off chamber and handles 2000 lbs. strip per hour.



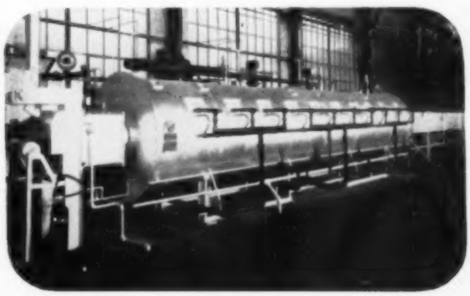
An EF special atmosphere furnace with flame preheating burn-off or oxidizing section, and controlled heating and cooling zones for producing various surface conditions on strip steel.

Designed and Built by

The Electric Furnace Co., Salem, Ohio

Gas Fired, Oil Fired and Electric Furnaces — For Any Process, Product or Production

This EF combination fuel fired and electrically heated strip processing unit provides extreme flexibility in heating, soaking and controlled cooling cycles for treating various grades of strip.



Stainless steel strip is bright or process annealed continuously in this EF gas fired special atmosphere tube muffle type furnace. It also handles other strip requiring lower temperatures.